NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN ANALYSIS OF THE INTEGRATION OF DECISION-MAKING MODELING WITH STATISTICAL/QUANTITATIVE BACKGROUND FOR MASTER"S LEVEL ANALYTICAL COURSES

by

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June 2000

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ABSTRACT

The purpose of this thesis is to integrate statistical/quantitative background material with Master's level analytical courses. This thesis first identifies the requirements for management education in terms of AACSB and NASPAA standards. Then, based on a comparative analysis of the country's top master's of business administration (MBA) programs and Naval Postgraduate School's current Systems Management curricula, and a survey conducted among SM faculty members, it integrates the decision-making modeling with statistical/quantitative background material for master's level analytical courses. The structure of the MS in Management at NPS, while satisfying the requirements of both AACSB and NASPAA is similar to the top management schools' MBA programs in the United States. However, top management schools' statistical/quantitative course sequence generally has four courses, providing more statistical/quantitative background material than those three of NPS. Additionally, the contents of these three courses are not offered in adequate depth and some topics are duplicated. The new sequence and the contents of these courses are proposed based on a survey conducted among SM faculty members.

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I. INTRODUCTION

> The goal of the management education is to bring the challenges of business alive, so that students learn how to tackle difficult, complex problems—by probing, discussing, and integrating, working together toward an understanding much deeper than ever could be achieved on their own. Students learn what it feels like to exercise judgment, make decisions, and take responsibility. In so doing, they must sharpen their skills of effective communication and be able to persuade, synthesize, and adapt.
>
> Kim B. Clark, the Dean of HBS Faculty

The nature of business is continuously changing, driven by powerful forces of globalization, technological innovation, and intense competition. These forces are creating a future requiring different management skills from todays. In the 21st century the leaders and general managers will have to stand poised to make a real difference in the world for the coming decades. The challenges that the managers will face in the future come from:

- Strong and growing global economic forces,
- Conflicting values,
- Changing technology in products and processes, and
- Demographic diversity among employees and customers. [Ref. 1]

21st century managers will also be leaders as well. As a leader of an organization, any manager must be able to handle successfully the followings:

- Analyze problems,

- Think and plan strategically,
- Write and speak,
- Build and support team work,
- Translate technical issues,
- Grasp systems thinking,
- Persuade others.

All these contribute to the uncertainty of management environment and managerial decisions that a manager will have to face. Business managers must have the capacity to assimilate new technological changes and transform strategies, processes, and organizations to be successful.

In order to prepare today's students but future managers to these challenging management environments, management education should stimulate intellectual and personal growth by building deep, practical knowledge and fostering real-world applications. In this environment, management education should also prepare students to contribute to their organizations and the larger society and to grow personally and professionally throughout their careers.

In military environment, despite the major functions are different from the civilian environment, the managerial skills are almost the same. Though the battle environment will change in the future, the main managerial side of the military officer will still remain the same—managing people and systems, and making decisions. Because of the

challenges, continuous changes and innovations a military officer should be not only a commander but also a leader and a manager. Therefore it is inevitable to educate military officers as managers and leaders to be able to handle difficult challenges, make correct decisions at the right time and right place, and make use of the modern technology.

A. PURPOSE AND OBJECTIVES

Graduate management education requires students to master new concepts and techniques quickly to benefit fully from their educational experience. Statistical/Quantitative aptitude is a prerequisite to successful participation in the program, and candidates should provide evidence of that aptitude in their applications.

Nevertheless, because of the diversity of students and their academic backgrounds, it is almost impossible to have all the applicants to have the same statistical/quantitative skills. To draw maximum benefit from the diverse range of experiences within each class, management students must first develop a common vocabulary of skills and technology in key areas.

The goal of this thesis is first to identify the analytical background requirements of management education in terms of The International Association For Management Education (AACSB) and The National Association of Schools of Public Affairs and Administration (NASPAA) standards. Then, based on a comparative analysis of the country's top master of business administration (MBA) programs and Naval Postgraduate School's current Systems Management curricula, we will integrate the decision-making

modeling and statistical/quantitative background material for master's level analytical courses.

This research will only focus on the analytical and statistical/quantitative courses in the proposed DoD MBA program. The research will provide a guideline for the sequence and the contents of the analytical courses to be taught in the program.

B. RESEARCH QUESTIONS

This integration process of decision-making modeling and statistical/quantitative background material for master's level analytical courses will research the following questions:

Primary,

- What should the core quantitative/statistical courses in an MBA program and sequence and contents of these courses?

Secondary,

- What are the requirements for management education in terms of AACSB and NASPAA standards?
- What are the analytical contents of top management schools?
- Why do we need to integrate decision-making models with quantitative/statistical background?
- What are the most appropriate course sequence and contents for the proposed courses?

C. SCOPE

In our research, we want to provide an analysis of course contents (topics, outlines and statistical/quantitative background) to support the integrated analytical and quantitative courses for DoD MBA program.

We will combine various analytical and statistical/quantitative backgrounds necessary for this program and we will determine the sequencing of course topics in this program by using Naval Postgraduate School's Systems Management curricula as our model.

D. METHODOLOGY

The methodology used in this thesis research will consist of the followings:

- Conduct a literature review of research on analytical requirements of management education.
- Research top management schools' MBA programs for their analytical contents.
- Conduct a literature review of the Systems Management curricula and its mission.
- Conduct a survey and interviews with NPS professors for the sequence and contents of the statistical/quantitative courses.
- Determine what statistical/quantitative background materials are needed to support the decision-making models.

- Develop a sample course sequence and contents by integrating statistical/quantitative background materials with decision-making models.

- Conclusions and recommendations based on the results of proposed course sequence and contents.

E. THESIS ORGANIZATION

This thesis continues in Chapter II with the analytical requirements for management education in terms of The International Association For Management Education (AACSB) and The National Association of Schools of Public Affairs and Administration (NASPAA) standards.

Chapter III analyzes the analytical contents of top management schools.

Chapter IV presents the current situation at Naval Postgraduate School's System Management Department and conducts a survey about the statistical/quantitative background requirements for master's level analytical courses.

Chapter V analyzes the results of the survey and determines the course contents of the statistical/quantitative courses in Systems Management Department.

Finally, Chapter VI consists of summary, conclusions, and thoughts on the applicability of the proposed MBA program for DoD.

II. ANALYTICAL REQUIREMENTS FOR MANAGEMENT EDUCATION

This chapter provides requirements for management education in terms of The International Association For Management Education (AACSB) and The National Association of Schools of Public Affairs and Administration (NASPAA) standards. It mainly focuses on the analytical requirements for the management education. This information is necessary for the integration of decision-making modeling with statistical/quantitative background for master's level analytical courses.

A. GENERAL

The complex demands on management education mirror the demands on organizations and managers. Challenges come from

- Strong and growing global economic forces,
- Conflicting values,
- Changing technology in products and processes, and
- Demographic diversity among employees and customers.

In this environment, management education must prepare students to contribute to their organizations and the larger society and to grow personally and professionally throughout their careers. The objective of management education accreditation is to assist programs in meeting these challenges. [Ref. 2]

Accreditation focuses on the quality of educational activities. Standards set demanding but realistic thresholds, challenge schools to pursue continuous improvement, and provide guidance for improvement in educational programs.

All schools share a common purpose--the preparation of students to enter useful professional and societal lives. Interaction among students and faculty accomplishes this purpose most directly. Accordingly, the accreditation review focuses on a school's clear determination of its mission, development of its faculty, planning of its curricula, and delivery of its instruction. In these activities, each school must achieve and demonstrate an acceptable level of performance consistent with its overall mission while satisfying AACSB/NASPAA standards.

As part of each school's effort to prepare its students for future careers, the school should provide a total educational experience that emphasizes conceptual reasoning, problem-solving skills, and preparation for life-long learning.

The process of accreditation provides a common reference point for quality and performance in management education for all AACSB and NASPAA members. To be accredited, a school must satisfy AACSB/NASPAA standards. However, certain standards or portions of standards apply differentially, depending on the various missions and objectives of different schools. This chapter mainly describes the analytical standards involved in the accreditation process.

B. THE INTERNATIONAL ASSOCIATION FOR MANAGEMENT EDUCATION (AACSB) STANDARDS

AACSB is a non-profit organization of educational institutions, corporations and other organizations devoted to the promotion and improvement of higher education in business administration and management. Organized in 1916, AACSB is the premier accrediting agency for bachelor's, master's and doctoral degree programs in business administration and accounting. AACSB accreditation standards consist of different categories: [Ref. 3]

1. Preamble,
2. Preconditions,
3. Mission and Objectives,
4. Faculty Composition and Development,
5. Curriculum Content and Evaluation,
6. Instructional Resources and Responsibilities,
7. Students,
8. Intellectual Contributions.

However, only the standards related to mission and objectives, curriculum content and evaluation, and students are listed below.

1. Standards Related to Mission and Objectives [Ref. 4]

The school should articulate its mission as a guide to its view of the future, its planned evolution and its infrastructure and use of resources. The accreditation evaluation process for a school is linked to its mission. These standards are as follows:

> M.1: The school must have a clear and published mission statement that is subjected to periodic review and revised as needed.
>
> M.2: The school's mission must be appropriate to higher education for business and management and consonant with the mission of the institution of which it is a part.
>
> M.3: The school must specify the educational objectives of each degree program offered and identify the characteristics of students and other constituents served by each of those degree programs.
>
> M.4: The school must specify its relative emphasis on teaching, intellectual contributions, and service.
>
> M.5: The school's activities must be consistent with its mission.

2. Standards Related to Curriculum Content and Evaluation [Ref. 5]

Curricula are central to the implementation of degree programs. Creating and delivering high quality curricula requires planning and evaluation. Similar academic objectives may be achieved through curricula with different structures and approaches. Undergraduate business curricula provide a broad context within which education for business is set. These curricula combine general education and basic study of business. Master's curricula in business provide a distinctly professional perspective. Master's of Business Administration (MBA) degree programs prepare students with a general managerial perspective.

a. C.1 Curriculum Content

C.1.1 Perspectives: Undergraduate and MBA

C.1.1: Both undergraduate and MBA curricula should provide an understanding of perspectives that form the context for business. Coverage should include:

- ethical and global issues,
- the influence of political, social, legal and regulatory, environmental and technological issues, and
- the impact of demographic diversity on organizations.

C.1.2 Undergraduate

C.1.2.a: Each undergraduate curriculum should have a general education component that normally comprises at least 50 percent of the student's four-year program.

C.1.2.b: The curriculum should include foundation knowledge for business in the following areas:

- accounting,
- behavioral science,
- economics, and
- mathematics and statistics.

C.1.2.c: The business curriculum should include written and oral communication as an important characteristic.

C.1.2.d: The school should state additional requirements for completion of the undergraduate business degree consistent with its mission. Majors or specializations should be consistent with the institutional mission and the availability of resources.

C.1.2.e: The school should require that at least 50 percent of the business credit hours required for the business degree be earned at the degree-awarding institution.

C.1.3 MBA and Other General Management Master's Programs

C.1.3.a: The curriculum should include instruction in the following core areas:

- financial reporting, analysis and markets,
- domestic and global economic environments of organizations,
- creation and distribution of goods and services, and
- human behavior in organizations.

Normally, these MBA core areas should require a minimum of 18 semester hours if taken at the graduate level. Part or all of this requirement may be completed at the undergraduate level.

C.1.3.b: The MBA curriculum normally should require a minimum of 30 semester hours beyond the MBA core areas (C.1.3.a). A minimum of 18 hours is required in courses outside the area of specialization, if any.

C.1.3.c: Basic skills in written and oral communication, quantitative analysis, and computer usage should be achieved either by prior experience and education, or as part of the MBA curriculum.

C.1.3.d: Each school's curriculum planning process should set additional requirements consistent with its mission and goals. The program also should allow adequate elective material for reasonable breadth.

C.1.3.e: The curriculum should integrate the core areas and apply cross-functional approaches to organizational issues.

b. C.2 Curriculum Planning and Evaluation

C.2.1 Curriculum Planning

C.2.1: The curriculum for each degree program should be the result of a curriculum planning process and should be consistent with the school's mission.

C.2.2 Monitoring of Programs for Effectiveness

C.2.2: Each degree program should be systematically monitored to assess its effectiveness and should be revised to reflect new objectives and to incorporate improvements based on contemporary theory and practice.

3. Standards Related to Students [Ref. 6]

A direct link exists between a school's mission and the characteristics of the students served by the educational programs. Thus, program design and student selection are interdependent processes. Careful planning and execution of these processes are necessary.

a. S.1 Student Selection

S.1.a: The school should select students consistent with its mission.

S.1.b: The school should demonstrate continuous efforts to achieve demographic diversity in its student enrollment.

S.1.c: The policies for admission to business degree programs at the baccalaureate level should be clear. Retention policies for baccalaureate students should be consistent with an objective of producing high quality graduates.

S.1.d: Admission policies at the graduate level normally limit selection of students to holders of the baccalaureate degree. Candidates admitted must be qualified for the program to which they are admitted. Retention policies for graduate students should be consistent with an objective of producing high quality graduates.

C. THE NATIONAL ASSOCIATION OF SCHOOLS OF PUBLIC AFFAIRS AND ADMINSTRATION (NASPAA) STANDARDS

The National Association of Schools of Public Affairs and Administration is an international membership organization, which exists to promote excellence in public service education. This professional education association is dedicated to the advancement of education, training and research in public policy and administration.

NASPAA has contact with many federal, state and local agencies and national public interest groups concerned with improving the quality of public management.

The NASPAA Executive Council expresses their appreciation to the current Joint Committee and their predecessors for their work in developing guidelines and expresses the hope that they will be useful to educational institutions desiring to develop such program concentrations within the Master of Public Administration (MPA) Curriculum, which is the most common degree, and also may be known as a master of governmental administration, a master in public affairs, a master of international relations or a number of other specific concentrations.

The purpose of a graduate program in public affairs and administration is to prepare individuals for positions of leadership in the public sector. The core curriculum typically covers the following areas:

- Political and legal institutions and processes,
- The economic and social systems and forces,

- The organizational and managerial skills and practices,
- Concepts and techniques of financial administration,
- Techniques of analysis, including quantitative, economic and statistical methods and computer systems.

These core elements constitute the building blocks for a diverse field of study. The choices range from city management and international affairs to personnel administration and strategic planning.

The purpose of these standards for professional masters degree programs in public affairs, policy, administration is to promote and maintain educational quality. These standards are used in NASPAA's peer review and accreditation process conducted by the Commission on Peer Review and Accreditation. NASPAA is recognized by the Council for Higher Education Accreditation (CHEA) as a specialized accrediting agency to accredit masters degree programs in public affairs, policy, and administration. The directly relevant elements of NASPAA's standards are presented in the following parts: [Ref. 7]

1. Program Eligibility for Peer Review,
2. Program Mission,
3. Program Jurisdiction,
4. Curriculum: Common Core and Specializations,
5. Faculty,
6. Admission of Students,
7. Student Services,

8. Support Services and Facilities,
9. Off-Campus Programs.

As far as we are concerned, the standards related to curriculum and admission of students are presented below.

1. Standards Related to Curriculum Components [Ref. 8]

a. 4.2 Curriculum Components

The curriculum components are designed to produce professionals capable of intelligent, creative analysis and communication, and action in the public service. Courses taken to fulfill the common curriculum components shall be primarily for graduate students. Both the common and the additional curriculum components need to be assessed as to their quality and consistency with the stated mission of the program.

b. 4.21 Common Curriculum Components

The common curriculum components shall enhance the student's values, knowledge, and skills to act ethically and effectively:

In the Management of Public Service Organizations, the components of which include:

- Human resources,
- Budgeting and financial processes,

- Information, including computer literacy and applications.

In the Application of Quantitative and Qualitative Techniques of Analysis, the components of which include:

- Policy & program formulation, implementation, and evaluation,
- Decision-making and problem solving.

With an Understanding of the Public Policy and Organizational Environment, the components of which include:

- Political and legal institutions and processes,
- Economic and social institutions and processes,
- Organization and management concepts and behavior.

These area requirements do not prescribe specific courses. Neither do they imply that equal time should be spent on each area or that courses must all be offered by the public affairs, public policy, or public administration programs. Nor should they be interpreted in a manner that might impede the development of special strengths in a program.

A "basic understanding" implies a good exposure to the subject. Substantially, all of the Common Curriculum Components must be covered by required prerequisites and/or graduate work.

These common subject matter areas and competencies must be covered adequately in developing a master of public administration curriculum to serve the public

works sector. No program, which fails to reflect these requisites, can be considered in conformity with NASPAA's Standards. The manner in which this is achieved is the responsibility of each university. NASPAA utilizes a self-assessment and peer review process to assist institutions in determining strengths and weaknesses of their program.

c. 4.22 Additional Curriculum Components

NASPAA's specifications for this element of a masters program are designed to stimulate and recognize innovation in relating administration to particular fields. The requirements are defined flexibly as follows:

- Each program shall clearly define its objectives for additional work and the rationale for the objectives and shall explain how the curriculum is designed to achieve those objectives. The statement of objectives shall include any program specialization or concentrations and the main categories of students to be served (e.g., pre-service, in-service, full-time, part-time).
- If a program advertises its ability to provide preparation for specialization or concentration in its catalog, bulletin, brochures, and/or posters, evidence shall be given that key courses in the specialization or concentration courses may be offered by units other than the public affairs or administration program. The specialization and concentration courses shall not be substitutes for the common curriculum components.

d. 4.23 General Competencies

The common and additional curriculum components shall develop in students general competencies that are consistent with the program mission.

e. 4.3 Minimum Degree Requirements

In respect to minimum degree requirements, the NASPAA MPA Standards state that:

- Students with little or no educational background or professional experience in the common and additional curriculum components are expected to devote the equivalent of two academic years of full-time study to complete the professional master's degree program. Where students have had strong undergraduate preparation in the common curriculum requirements or have been engaged in significant managerial activities, some of the subject matter requirements might be appropriately waived or reduced. Even in such cases, students ordinarily must spend the equivalent of a calendar year of full- time study in formal academic work, exclusive of an internship, to obtain the professional master's degree. A calendar year is defined as two semesters and a summer session of at least eight weeks in duration or four quarters (exclusive of internship) of full-time academic work.

f. 4.4 Internships

- A carefully planned internship experience shall be made available by the program and students who lack a significant professional work background shall be strongly encouraged to take advantage of it. The program shall provide on-going academic supervision. Internship programs shall generally reflect NASPAA's internship guidelines.

2. Standards Related to Admission of Students [Ref. 9]

a. 6.1 Admission Goals and Standards.

- Admission goals, policy and standards, including academic prerequisites, should be clearly and publicly stated, specifying any differences for pre-service, in-service or other categories of students, and reflecting specific concern for the representation of minorities, women, and persons with disabilities. Programs and plans designed to

insure student diversity shall generally reflect NASPAA's Diversity Guidelines.

b. 6.2 Baccalaureate Requirement

- Admission shall normally be limited to applicants with a baccalaureate degree from a regionally accredited institution and appropriately evaluated applicants from non-U.S. universities.

c. 6.3 Admission Factors

- Admission shall be limited to applicants showing good potential for success in professional graduate study and public service. Admission standards shall include several of the following factors about each applicant: (a) performance on the aptitude part of the Graduate Record Exam or the Graduate Management Admissions Test, or equivalent tests; (b) undergraduate grade point average and trend of grades; (c) rank in graduating class; and (d) biographical and career interest data and essays; and (e) evaluation of the quality of professional experience. These admissions standards should recognize the need for different measures to establish the criteria of excellence between pre-service and in-service students. Final judgment on admission shall be based on a combination of several of the above indicators rather than on a single criterion in order to increase the quality of professional personnel entering the public service.

D. SUMMARY

In this chapter, we mainly provided analytical requirements for management education in terms of AACSB and NASPAA standards.

All schools share a common purpose—the preparation of students to enter useful professional and societal lives. Standards set demanding but realistic thresholds, challenge schools to pursue continuous improvement, and provide guidance for improvement in master's level educational programs. As part of each school's effort to

prepare its students for future careers, the school should provide a total educational experience that emphasizes conceptual reasoning, problem-solving skills, and preparation for life-long learning. These preparation efforts are especially important to students with limited background and experience.

As we look at the requirements for the curriculum components of a master's level management education, we can see that the curriculum should include instruction in following core areas:

- Financial reporting, analysis and markets,
- Domestic and global economic environments of organizations,
- Creation and distribution of goods and services,
- Human behavior in organizations,
- Information, including computer literacy and applications.

In order to integrate these core courses with decision-making modeling each student should be proficient enough to make use of the application of quantitative and qualitative techniques of analysis which include:

- Policy and program formulation, implementation, and evaluation,
- Decision-making and problem solving.

These area requirements do not prescribe specific courses. A basic understanding implies a good exposure to the subject. Substantially, all of the curriculum components must be covered by required prerequisites and/or graduate work.

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III. ANALYTICAL CONTENTS OF TOP MANAGEMENT SCHOOLS

This chapter provides a brief review of the common core statistical/quantitative courses of top management schools' MBA programs. First, it determines the top schools in management education; then, it investigates these schools' core courses and comes up with the common core statistical/quantitative courses. Finally, it provides a summary of the contents of these courses.

A. GENERAL

There are many organizations that compile and rank business schools. US News & World Report (USN&WR) and Business Week are the most notable of these organizations. Although their methods for determining the top management schools are different, the schools that they identify are always similar to each other. The rankings may differ but mostly the top schools in the list are common. In our research, we used USN&WR business school rankings. USN&WR rank graduate programs by using a combination of statistical data and reputation data. The business schools used in determining the ranking are provided by the AACSB, which mainly focuses on American schools. USN&WR ranks business schools every year. The rankings we used in our research are that of the year 1999.

1. Top MBA Programs Ranking

USN&WR rank schools in different categories. The main category is based on the combination of all disciplines in MBA programs. Based on the USN&WR ranking, the 15 top business schools are as follows:

RANK	SCHOOL
1	Stanford University (CA)
2	Harvard University (MA)
2	Northwestern University (IL)
2	University of Pennsylvania (PA) (Wharton)
5	Massachusetts Institute of Technology (MA) (Sloan)
6	University of Chicago (IL)
7	Columbia University (NY)
7	University of Michigan—Ann Arbor (MI)
9	Duke University (NC)
10	University of California-Los Angeles (CA) (Anderson)
11	University of Virginia (VA) (Darden)
12	Dartmouth College (Tuck) (NH)
13	New York University (NY)
14	University of California-Berkeley (CA)
15	Yale University (CT)

Table 1. Top 15 MBA Programs in the USA. From Ref. [10].

2. Top MBA Programs Ranking in Business Specialties

	School	Ranking
1	Harvard University (MA)	1
2	Stanford University (CA)	2
3	Northwestern University (Kellogg)	3
4	University of Michigan-Ann Arbor	4
5	University of Pennsylvania (Wharton)	5
6	Dartmouth College (Tuck) (NH)	6
7	University of Virginia (Darden)	7
8	Duke University (Fuqua) (NC)	8
9	Columbia University (NY)	9
10	UCLA (Anderson)	10

Table 2. Top Ten Schools in General Management. From Ref. [11].

	School	Ranking
1	MIT-Sloan	1
2	University of Chicago	2
3	Carnegie Mellon University (PA)	3
4	Stanford University (CA)	4
5	University of Pennsylvania (Wharton)	5
6	University of California-Berkeley (Haas)	6
7	Northwestern University (Kellogg)	7
8	University of Michigan-Ann Arbor	7
9	Columbia University	9
10	Purdue University (Krannert)	10

Table 3. Top Ten Schools in Quantitative Analysis. From Ref. [12].

	Schools	Ranking
1	MIT-Sloan	1
2	Carnegie Mellon University	2
3	Purdue University-Krannert	3
4	Harvard University	4
5	Stanford University	5
6	University of Pennsylvania (Wharton)	6
7	University of Michigan-Ann Arbor	7
8	Northwestern University (Kellogg)	8
9	Indiana University-Bloomington	9
10	University of Chicago	10

Table 4. Top Ten Schools in Operations/Production Management. From Ref. [13].

As it can be seen in the tables above, although the rankings are different in each discipline, most of the schools are the same in all three tables. Starting from this point, we are going to focus on the common schools in these disciplines.

B. TOP MANAGEMENT SCHOOLS' PROGRAMS

In this section, we are going to put forward the MBA required core course listings of these common schools. There are different course listings for different schools. But we are going to look only to the core courses of MBA programs. Our main focus will be on analytical courses.

1. Harvard University

Harvard Business School (HBS) MBA program comprises of two years, each of which has two terms. All students pursue the same course of study in the first two terms and, together, build a broad foundation of general management concepts and skills. During the second year, students choose from an unparalleled range of elective courses, which enables them to synthesize the functional skills developed in the required curriculum into a more complete understanding of the firm as a total enterprise. Along with these lines, we are going to focus on the first year courses.

The courses in the first term use the lens of general management to focus on the internal functional operations of business enterprises. The only statistical/quantitative course is: [Ref.14]

- Technology and Operations Management: The course enables students to develop the skills and concepts needed to ensure the ongoing contribution of a firm's operations to its competitive position. Topics encompass all elements of coherent operating systems-process analysis, cross-functional and cross-firm integration, product development, and technology and operations

strategy. Current cases that illustrate performance drivers of quality, cost, speed, and flexibility include Toshiba's creative approach to efficient, yet flexible, assembly of laptops; Braun's emergence as a worldwide design, production, and marketing company; Toyota's just-in-time capabilities; Barilla's efforts to decrease supply-channel costs by increasing coordination with its distributors and retailers; and changes in employee behavior at Alcoa that have increased quality and workplace safety.

In Term II the focus moves outward to encompass the relationship of the organization to larger economic, governmental, and social environments.

Harvard Business School MBA students must first develop a common vocabulary of skills and terminology in key areas. To facilitate this process, the school provides admitted students with online tools for self-assessment and review in areas such as accounting, business writing, class presentation, computer skills, general business knowledge, and quantitative methods. Students must successfully complete this academic preparation program before enrolling at HBS. If necessary some students may be required to use additional resources, such as local courses and an intensive on-campus Analytics Program, to improve their skills in some subjects. This requirement results in a shared platform of skills essential for success at HBS.

Students begin building on these skills during Foundations, a three-week program that launches the MBA curriculum. This program is designed to ensure that students master skills and conceptual frameworks that will enhance and inform their learning throughout the curriculum. Students are graded in Foundations based on basic standards of completion and proficiency. The statistical/quantitative courses in Foundations curriculum are:

- Quantitative Methods: Students establish a basic set of concepts, skills, and tools as building blocks for quantitative analysis in the required courses.

- Leadership, Values, and Decision Making: Students begin to develop an ethical framework to use as a guide in decision-making. Through a series of complex cases centered on high-stakes decisions, students examine reasoning processes that can help managers make sound decisions and methods managers use to build responsible organizations guided by a sense of purpose and ideals.

2. Stanford University

Stanford Graduate School of Business (GSB) MBA program is a two-year program. There are three quarters in each year—fall quarter, winter quarter, and spring quarter. The first year courses are common to all MBA students. The second year courses are determined based on the concentration of students. A pre-term academic program is required for all incoming MBA students before the Fall Quarter begins. The Pre-Term Program lets all first-years brush up on basic skills before the core begins. The only analytical course in this program is: [Ref. 15]

- Modeling and Analysis: This course introduces modeling: the building, using, and interpretation of computer-based models that aid managers in making decisions. Students will gain some experience in the art of translating verbal descriptions of managerial decision situations into well-organized spreadsheet-based models and will learn about finding the optimal solutions of these models when appropriate. The Excel spreadsheet application and its optimization tools will be the primary vehicles for exploring the value of these approaches to decision support.

The actual MBA program includes a variety of courses. Our main focus is on the statistical/quantitative courses. These courses are as follows: [Ref. 16]

- Data and Decisions: This course introduces fundamental concepts and techniques for analyzing risk and formulating sound decisions in uncertain environments. Approximately half of the course focuses on probability theory and decision analysis, including decision trees, decision criteria, the value of information, and simulation techniques. The remainder of the course examines statistical methods for interpreting and analyzing data, including sample concepts, regression analysis, and hypothesis testing. Applications include

inventory management, demand analysis, lotteries and gambling, portfolio analysis, insurance, auctions, surveys and opinion polls, environmental contamination, failure analysis, and quality control. The course emphasizes analytical techniques and concepts that are broadly applicable to business applications.

- Operations: This course focuses on basic managerial issues arising in the operations of both manufacturing and service industries. The objectives of the course are to familiarize students with the problems and issues confronting operations managers and to introduce language, conceptual models, and analytical techniques that are broadly applicable in confronting such problems. The spectrum of different process types used to provide goods and services is developed, and then examined through methods of process analysis and design.

3. University of Chicago

University of Chicago MBA program is a two-year program. The first year is a common program for all MBA students. Students choose their majors in the second year and take their courses accordingly. The first year courses are separated into categories. In order to get an MBA degree at the University of Chicago, a student must fulfill the specified requirements for each category of courses. There are five categories: [Ref. 17]

1. LEAD (Leadership Exploration and Development),
2. Foundations,
3. Breadth Requirements,
4. General Management,
5. Electives.

The students must take one course in LEAD, three courses in Foundations, four courses in Breadth Requirements, two courses in General Management, and 11 courses in

Electives. The eleven elective courses determine the students' concentration in any of the specialties. The statistical/quantitative courses given in these categories are as follows:

a. LEAD

A one-quarter course required for campus students taken during the first year in residence.

b. Foundations

- Business Statistics: This course is designed to teach the basic statistical concepts and tools needed for business applications and most GSB courses. The topics covered are: (i) descriptive statistics and plots used to summarize data; (ii) random variables and expectation; (iii) modeling and inference: population and sample quantities, confidence intervals, hypothesis tests and p-values; (iv) simple linear regression; (v) introduction to multiple regression; (vi) basic time series: autocorrelation, auto regression, the random walk. Statistical software (such as MINITAB) is used.

c. Breadth Requirements

- Data Driven Market Analytics: Although many of the methods employed in the course are useful in business-to-business marketing (direct marketing, especially), the primary emphasis is on analysis of consumer demand. Examples from the consumer packaged goods industry and direct marketing of financial services are used. This course makes intensive use of Excel and MINITAB and the Windows computing environment. The data has been extracted and organized for use in MINITAB; this allows the student to concentrate on learning modeling tools without a large investment in computing or data manipulation methods.

- Operations Management: Business Process Fundamentals: This core course focuses on understanding levers for structuring, managing, and improving a firm's recurring business processes to achieve competitive advantage in customer responsiveness, price, quality, and variety of products and services. These levers are as applicable to banks, hospitals, and brokerage firms, for example, as to traditional manufacturing. Processes within firms, as well as between firms, i.e. supply chains, are explored. The fundamental principles underlying

state-of-the-art practices, such as Quick Response, Just-in-Time and Time-Based Competition, are explored so that students learn to critically evaluate these and other operational improvement programs.

d. General Management

- Managerial Decision Making, Managing in Organizations: This course has two goals: descriptive and prescriptive. The descriptive goal is to understand how managers actually make decisions. The prescriptive goal is to help students become better decision makers. Through readings, demonstrations, and cases, students first understand why managers are susceptible to certain decision-making biases and therefore often make less than optimal decisions. The course also discusses the managerial implications of these biases for consumer, organizational, and financial decision-making. The course also develops a framework that helps managers and organizations make better decisions. In particular, students learn how to (1) structure decision problems; (2) identify the objectives of a particular decision problem, and make trade-offs between conflicting objectives (including risk and return); and (3) make the subjective judgments that are critical components of any important decision problem.

4. Massachusetts Institute of Technology (MIT)-Sloan

All students in the MBA program must complete a required fall-term core curriculum in addition to 144 units of electives. The fall-term begins with an intensive Orientation Week and consists of a common experience spread across six subject areas. Three of these subjects are known as perspectives subjects because they address managerial problems from three basic paradigms: a market-centered or economic approach, a data-centered or modeling approach, and an organizational or behavioral approach. These perspectives on management are taught using both practical tools and theoretical rigor to help prepare students for further course work at Sloan as well as for

their eventual career choice. The subjects themselves are the result of diverse groups of faculty covering both disciplinary and applied or functional course material.

The other foundations of the fall core include accounting (including both financial and managerial concepts), corporate strategy, and managerial communications. These subjects, together with the perspectives subjects, give students the breadth necessary to move into other areas of study at Sloan. All subjects provide the basis of the shared experience that students carry through the rest of their time at Sloan and into their careers. The only statistical/quantitative course in fall-term is as follows: [Ref. 18]

- Data, Models, and Decisions: Introduces students to key techniques for using data to make informed management decisions. Covers introductory probability, statistics, decision analysis, and optimization. Emphasizes managerial applications in such areas as operations management, marketing, and finance.

After completing the fall-term students select their elective courses according to their concentrations in any track.

5. University of Michigan-Ann Arbor

The full time MBA program consists of 60 semester hours completed over two full academic years. Students enter early in September, complete the first year in late April of the following year, and have a four-month summer work period before returning in September for the second year of the program. Courses offered in the first year of the program establish a basic understanding of the functional responsibilities of an organization. During the second year of the program, students integrate concepts learned in the first year and take electives in the area of interests while completing all degree

requirements. The statistical/quantitative courses in core MBA program are as follows: [Ref. 19]

- Applied Business Statistics: Examines statistical tools for business. Topics include statistical quality control and quality management, correlation and regression analysis for interpretation of multivariate datasets, quantitative forecasting methods, and an emphasis on business applications through computer-based projects.

- Operations Management: Introduces basic concepts and issues in managing production systems. Major topics include quality assurance, line balancing, project management, production planning and scheduling, and inventory control

6. Carnegie-Mellon University

Carnegie-Mellon Graduate School of Industrial Administration program is a two-year full time program. There are four quarters (Mini) in the first year and two quarters in the second year. The core statistical/quantitative courses in these quarters are as follows: [Ref. 20]

First year, Mini-I

- Probability and Statistics-I: This course teaches students the fundamental principles of probability and statistics, with special emphasis on how these principles can be applied to business decision-making problems. The course covers basic tools for summarizing numerical data, the laws of probability, Bayes' Theorem, discrete and continuous random variables (with special emphasis on the binomial, Poisson, exponential, and normal distributions), expected value and variance, point estimation of means and proportions, confidence intervals for means and proportions, hypothesis testing involving means and proportions, and the basic elements of statistical decision theory. The course illustrates these concepts using examples drawn primarily from the business world.

- Quantitative Methods for Management Science: This course covers fundamental tools for quantitative analysis in the management sciences. Topics include linear algebra, nonlinear optimization, linear programming and integer programming. Emphasis is placed on linear programming, particularly on modeling business applications and on sensitivity analysis. The course follows a practical spreadsheet-based approach to provide hands-on experience with software such as excel solver.

Mini-II

- Probability and Statistics-II: This course develops methods for analyzing statistical relationships inviting several variables. Techniques studied in the course are useful for a variety of business applications in accounting, finance, marketing, production and other areas. The course emphasizes formulating models and using them for decision-making prediction. Topics include assessing the accuracy of coefficient estimates and predictions (interval estimation and hypothesis testing), and the more general problem of assessing the suitability of a model (specification analysis). The course involves extensive hands-on work with state-of-the-art software and data from variety of real-world applications.

- Decision Models: This course (previously titled 'Introduction to Operations Research') develops analytical models for decision-making. The emphasis in this course is on handling uncertainty and multiple objectives. The techniques covered include simulation, queuing, decision trees, stochastic programming, and multi-objective techniques. Examples are drawn from finance, operations, and other areas of business and may include capacity expansion planning, evaluating real options, financial decision-making, and technology selection problems.

Mini-III

- Production and Operations Management: The production and distribution of services and manufactured goods is a complex task involving the management of material, information, technology and people. When properly managed operations can be a source of competitive advantage, resulting in high quality customized goods produced and delivered in a timely manner at minimal total cost. This course will demonstrate models and practices that enable a company to achieve these objectives. Topics include: supply chain management, inventory and materials management, production planning and control, productivity improvements, quality control, JIT, flexible manufacturing, capacity allocation, forecasting, and resource planning. Current issues such as global supply chains and the Internet will also be discussed. Cases supplement the lectures.

7. University of Pennsylvania-Wharton

Wharton's MBA program is a two-year program. The first year focuses on the management core providing fundamental business skills, knowledge, and perspectives. Organized into four tightly focused six-week quarters, the first year exposes students to a breadth of subjects and approaches. Second year students build upon the foundation of core curriculum as they develop expertise in their chosen fields. With 17 majors, more than 25 concentration areas, and over 200 elective courses, the Wharton MBA degree is designed to be as varied as the individuals who come to the school. The five-week pre-term courses prepare students for the core MBA courses. The statistical/quantitative courses in the pre-term are: [Ref. 21]

- Math Proficiency: This course is for MBA candidates whose mathematical skills are insufficient for the core curriculum courses. Some students will be urged (on the basis of their backgrounds and GMAT scores) to take the course during the week before Pre-Term. All students take a *mathematics proficiency exam* at the beginning of Pre-Term. This is a 15-hour course that covers basic arithmetic and algebraic skills (manipulation of exponents and other symbols, expressing and plotting of functions, solving simultaneous equations, etc.) and the basic notions and techniques of differential and integral calculus. The theme of the course is the notion of a mathematical function. Included in the survey of techniques and ideas is a preview of how they appear in later courses.
- Statistical Analysis for Management: This course introduces statistical ideas as they apply to managers. Two key ideas dominate the material: summarizing and describing data, and modeling variability and randomness using probability models. The focus of the presentation is on understanding the rationale for modern statistical methods and developing critical judgment in the use of these methods. Extensive use of computer software replaces much of the standard demand for calculation and frees time for interpretation and evaluation. Topics covered in the course include: randomness and variability, graphical summarization, quality control, probability, sampling, estimation, confidence intervals, and hypothesis tests.

The core courses are given in two years, each of which consists of four tightly focused quarters. The statistical/quantitative courses given in each quarter are as follows:

a. First Quarter

- Statistical Analysis for Management: This course considers the use of two key statistical methodologies: regression analysis and experimentation. Regression analysis is a ubiquitous tool that permeates most of applied statistics. This course considers the application of regression in various contexts. The use of regression diagnostics and various graphical displays supplements the basic numerical summaries and provides insight into the validity of the modeling approach. The coverage of experimentation introduces the notion of a statistical experiment. It is shown how a manager can design an experiment that will yield reliable, appropriate answers to various business questions, such as how to combine factors to produce the highest quality-manufacturing scheme. The course also introduces the statistical methods used in the analysis of data from experiments. These methods, collectively known as the analysis of variance, provide an important addition to the standard suite of regression techniques. Specific important topics covered include least squares estimation, residuals and outliers, tests and confidence intervals, correlation and autocorrelation, collinearity, and randomization. The presentation relies upon computer software for most of the needed calculations, and the resulting style focuses on construction of models, interpretation of results, and critical evaluation of assumptions.

b. Second Quarter

- Operations Management--Quality and Productivity: This mini course emphasizes *processes.* A process is a set of interrelated work activities characterized by specific inputs and value-adding tasks that produce specific outputs. In the first part of the course students see examples of a number of processes and learn how to describe a process with a flow diagram. Students also learn to measure key process parameters like capacity and lead time, and to improve a process through approaches like finding and removing bottlenecks or better division of the work among the people involved in the process. The second part of the course focuses on process improvement and examines some classic ideas in quality management as well as recent ideas about restructuring processes for increased performance.

c. Fifth Quarter

- Decision Making Under Uncertainty: Fundamentals of modern decision analysis with emphasis on managerial decision making under uncertainty and risk. The basic topics of decision analysis are examined. These include payoffs and losses, utility and subjective probability, the value of information, Bayesian analysis, inference and decision-making. Examples are presented to illustrate the ideas and methods. Some of these involve: choices among investment alternatives; marketing a new product; health care decisions; and costs, benefits, and sample size in surveys.

d. Sixth Quarter

- Managerial Decision-Making: The course builds on recent studies to gain an understanding of the simplified rules of thumb and apparent systematic biases individuals utilize in making judgments and choices under uncertainty. The first part of the course focuses on individual behavior using examples from management, decision sciences, finance, health care, insurance and marketing to illustrate behavior. The second half deals with strategic decision making by groups and organizations when the parties have different objectives and options.

8. Columbia University

Columbia Business School MBA program is a two-year program, consisting of five terms. The program offers a pre-term review course before the core courses given in five terms. The pre-term review course, a four-week course, is designed to begin building teams and address the quantitative and computer skills needed to succeed in the program. It is required of all students and directly precedes the school year. The core statistical/quantitative courses given in each term are as follows: [Ref. 22]

a. First Term

- Managerial Statistics: Introduces students to basic concepts in probability and statistics of relevance to managerial decision-making.

Topics include basic data analysis, random variables and probability distributions, sampling distributions, interval estimation, hypothesis testing and regression. Numerous examples are chosen from quality-control applications, finance, marketing and management.

b. Second Term

- Decision Models: This half-term (six-week) course offers a brief introduction to computer-based models and their use in structuring information and supporting managerial decisions. It conveys an appreciation for the extraordinary scale and complexity of the information needed to manage effectively and demonstrates how decision models can serve to organize this information and provide tools for analyzing and improving the decision process. Specific topics include linear programming, multi-period planning models under uncertainty, nonlinear programs and Monte Carlo simulation.

- Operations Management: Provides a fundamental understanding of manufacturing and service operations and their role in the organization. Surveys a wide range of operations topics, including process flow analysis, inventory management, capacity planning, facilities location, total quality management, human resource management, technology management and manufacturing and service strategy. Deals with these topics through a managerial, applications-oriented perspective. Special emphasis is placed on the international dimensions of operations. The course is integrative in nature, emphasizing the fit and relationship of operations with other functions of the firm.

9. Purdue University

The Master of Science in Management (MSM) program of Krannert, Purdue University is a two-year program consisting of core courses in all the functional areas of management and offers students the option to specialize in a particular area of study. The core statistical/quantitative courses given in two semesters in each year are as follows: [Ref. 23]

a. Year One-Fall Semester

- Quantitative Methods I: Introduction to quantitative decision procedures under uncertainty. Applications of descriptive statistics, probability models, simulation models, interval estimates, and hypothesis testing to management problems. Managerial-oriented cases are used in instruction.
- Quantitative Methods II: A continuation of Quantitative Methods I. Applications of regression procedure, forecasting technique, and statistical design of experiment method to management problems. Managerial-oriented cases are used throughout the course.

b. Year One-Spring Semester

- Operations Management I: Operations management is concerned with managing (i.e., planning and controlling) the operations that an organization uses to produce goods and to provide services. The goals of this course are: First, to help students gain an exposure to the spectrum of operations-management activities and to the types of decisions that operations managers are involved in. Second, to help students to get insights into the basic trade-offs associated with operations-management decisions. Third, to introduce a variety of tools and techniques for helping operations managers reach and implement their decisions. Fourth, to expose students to recent developments in world-class operations. The course will employ a variety of pedagogies in order to reach its goals. Some classes will be lecture-oriented; others will involve general discussion. A mixture of plant tours, case analyses, and operations-research techniques will be used, as appropriate. An assortment of microcomputer exercises and/or tools will also be employed.

10. University Of California-Los Angeles (Anderson)—UCLA

Anderson's MBA curriculum has three main components: the management core, advanced electives, and Management Field Study. The curriculum provides students with a strong general management education. Since Anderson MBA students are not required to declare a major or concentration, they have great flexibility in tailoring their MBA

curriculum to their personal interests and career goals. They can build emphases in any of several functional and specialty areas.

The MBA program is a two-year, six-quarter program. There is a pre-term preparation program before the actual program starts. Management foundations are given in the pre-term program. The statistical/quantitative courses in the core management curriculum are as follows: [Ref. 24]

a. First Year Fall

- Data Analysis, Statistics, and Decision-Making: In-depth introduction to probability, decision theory, and statistical inference, with emphasis on solution to actual business problems.

b. First Year Winter

- Operations and Technology Management: Principles and decision analysis related to effective utilization of factors of production in manufacturing and non-manufacturing activities for both intermittent and continuous systems. Production organizations, analytical models and methods, facilities design, and design of control systems for production operations.

C. SEQUENCE OF STATISTICAL/QUANTITATIVE COURSES OF THE CORE MBA

All the schools we have researched have certain criteria for student admission. Students are required to have a background in basic quantitative concepts and computer skills to successfully complete the MBA program. Regarding the diversity of students, it is difficult for the school to have the students with the same level of background. To make sure that every student is proficient enough in these basic areas, most schools offer preparation programs for MBA. These preparation programs last from three to four

weeks. Having taken the preparation program, students become ready for the MBA program.

Along with the curriculum, other core statistical/quantitative courses are given. These core statistical/quantitative courses develop in the basic skills and help students' progress in the advanced decision-making modeling courses given in different disciplines/tracks of MBA program. All these courses are given in a sequence, as building blocks one on top of the other. Although course names differ from school to school, looking back at the programs we analyzed in the previous section, there is a common sequence of these statistical/quantitative courses as follows:

1. Probability and Statistics,
2. Quantitative Methods for Managers,
3. Data, Models, and Decisions,
4. Operations/Production Management.

D. CONTENTS OF ANALYTICAL COURSES

1. Preparation Program

As we mentioned before, many schools have preparation courses before the actual program starts. These programs are designed to begin building teams and address the quantitative and computer skills needed to ensure that students master skills and conceptual frameworks that will enhance and inform their learning throughout the curriculum. Students are graded in preparation program based on basic standards of completion and proficiency.

Computer assignments, especially spreadsheet applications, are an integral part of the coursework in the program. The goal is to have all entering MBA students familiar with Excel by the start of the actual program so that faculty in the core courses may begin using applications in their courses almost immediately.

Some of the students have highly sophisticated mathematics and engineering preparation, while others have a minimum of undergraduate work in mathematics. However, both faculty and students must be comfortable using quantitative concepts in order to complete core courses. Students establish a basic set of concepts, skills, and tools as building blocks for quantitative analysis in the required courses. In brief, this preparation program helps students be able to do the followings:

- Solve word problems using algebra,
- Understand financial notation,
- Read and interpret graphs and tables,
- Graph linear as well as nonlinear functions,
- Calculate the slope of a linear and a quadratic function,
- Calculate the area under a line segment,
- Identify maxima and minima of functions from their graphs,
- Solve a system of two linear equations,
- Understand and use exponents and logarithms.

In addition to basic mathematical skills discussed above, the preparation program also introduces statistical ideas as they apply to managers. Two key ideas dominate the material: summarizing and describing data, and modeling variability and randomness using probability models. The focus is on understanding the rationale for modern statistical methods and developing critical judgment in the use of these methods. Extensive use of computer software replaces much of the standard demand for calculation and frees time for interpretation and evaluation. Topics covered in the course include: randomness and variability, graphical summarization, quality control, probability, sampling, estimation, confidence intervals, and hypothesis tests.

2. Statistical/Quantitative Courses

a. Probability and Statistics

This course teaches students the fundamental principles of probability and statistics, with special emphasis on how these principles can be applied to business decision-making problems. The course covers basic tools for summarizing numerical data, the laws of probability, Bayes' Theorem, discrete and continuous random variables (with special emphasis on the binomial, Poisson, exponential, and normal distributions), expected value and variance, point estimation of means and proportions, confidence intervals for means and proportions, hypothesis testing involving means and proportions, and the basic elements of statistical decision theory. The course illustrates these concepts using examples drawn primarily from the business world.

Later the course develops methods for analyzing statistical relationships inviting several variables. Techniques studied in the course are useful for a variety of business applications in accounting, finance, marketing, production and other areas. The course emphasizes formulating models and using them for decision-making prediction. Topics include assessing the accuracy of coefficient estimates and predictions (interval estimation and hypothesis testing), and the more general problem of assessing the suitability of a model (specification analysis). The course involves extensive hands-on work with state-of-the-art software and data from variety of real-world applications.

b. Quantitative Methods

This course covers fundamental tools for quantitative analysis in the management sciences. Topics include linear algebra, nonlinear optimization, linear programming, integer programming, and simulation. Emphasis is placed on linear programming, particularly on modeling business applications and on sensitivity analysis. The course follows a practical spreadsheet-based approach to provide hands-on experience with software such as Excel solver.

c. Data, Models and Decisions

This course introduces the fundamental concepts and techniques for analyzing risk and formulating sound decisions in uncertain environments. The course considers the use of two key statistical methodologies: regression analysis and experimentation. Regression analysis is a ubiquitous tool that permeates most of applied statistics. This course considers the application of regression in various contexts. The use

of regression diagnostics and various graphical displays supplements the basic numerical summaries and provides insight into the validity of the modeling approach.

The coverage of experimentation introduces the notion of a statistical experiment. It is shown how a manager can design an experiment that will yield reliable, appropriate answers to various business questions, such as how to combine factors to produce the highest quality-manufacturing scheme. The course also introduces the statistical methods used in the analysis of data from experiments. These methods, collectively known as the analysis of variance, provide an important addition to the standard suite of regression techniques.

Specific important topics covered include least squares estimation, residuals and outliers, tests and confidence intervals, correlation and autocorrelation, collinearity, and randomization, multiple regression, basic time series. The presentation relies upon computer software for most of the needed calculations, and the resulting style focuses on construction of models, interpretation of results, and critical evaluation of assumptions.

d. Operations/Production Management

The production and distribution of services and manufactured goods is a complex task involving the management of material, information, technology and people. When properly managed operations can be a source of competitive advantage, resulting in high quality customized goods produced and delivered in a timely manner at minimal total cost. This course demonstrates models and practices that enable a company to

achieve these objectives. Topics include: supply chain management, inventory and materials management, production planning and control, productivity improvements, quality control, JIT (Just-in-time), flexible manufacturing, capacity allocation, forecasting, and resource planning. Current issues such as global supply chains and the Internet are also discussed. Cases supplement the lectures.

E. SUMMARY

This chapter provided a brief review of the common core statistical/quantitative courses of top management schools' MBA programs. First, we determined the top schools in management education according to USN&WR graduate schools ranking. We analyzed different categories of rankings based on disciplines. We found that despite the rankings are different for the top ten schools in different disciplines—general management, quantitative analysis, operations/production management, and the names of the schools in these lists are almost the same. We picked the most common ten schools from these lists and searched their MBA programs for the core courses and then came up with the sequence and contents of common core statistical/quantitative courses.

Second, we researched their programs. As we researched the programs, we saw that all the programs are two-year programs. However, the degree requirements are different for each school. Most of the programs start with a pre-term preparation program—three to four week program, which is designed to begin building teams and address the quantitative and computer skills to ensure that students master skills and conceptual frameworks that will enhance and inform their learning throughout the

curriculum. The first year of all MBA programs, which is designed to give the core courses, establishes a basic understanding of the functional responsibilities of an organization. During the second year of the program, students integrate concepts learned in the first year and take electives in the area of interests while completing all degree requirements.

All the core courses of all MBA programs are given in a sequence, as building blocks one on top of the other. Although course names differ from school to school, looking back at the programs we analyzed, we found that there is a common sequence of the statistical/quantitative courses as follows:

1. Probability and Statistics,
2. Quantitative Methods for Managers,
3. Data, Models, and Decisions,
4. Operations/Production Management.

Finally, we described the contents of these statistical/quantitative courses.

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IV. THE SYSTEMS MANAGEMENT DEPARTMENT AT NPS AND THE CONDUCT OF A SURVEY

This chapter begins by providing data on the Naval Postgraduate School's Systems Management Department. The data include mission and purpose of the department, curricula, prerequisites, core courses, and statistical/quantitative course sequence. Next, depending on the statistical/quantitative course sequence, graduate education analytical background requirement survey is conducted. Then, the raw data of the survey is offered. In the final section, we will analyze the survey results in terms of the need for integration for decision models with analytical background.

A. NAVAL POSTGRADUATE SCHOOL

The Department of Systems Management, the largest of the 15 academic departments and groups of the NPS is responsible for academic programs designed to educate officers and DoD civilian employees in a variety of functional management specialties. The department is a member of NASPAA and AACSB. Both NASPAA and AACSB accredited the Master of Science in Management program.

The mission statement of the Department of Systems Management is as follows: [Ref. 25]

- To improve the managerial capabilities and leadership qualities of US and international officers and government civilians through graduate education, research, and professional service.
- To develop students' abilities to analyze, think critically, and take intelligent action so they can more effectively carry out their professional

responsibilities, and lead their organizations in complex, and sometimes life-threatening, environment.

- To conduct research that supports military decision-making, problem solving, and policy setting, improves administrative processes and organizational effectiveness, contributes knowledge to academic disciplines, and advances the mission of graduate education.

- To provide professional expertise that supports the development of the Naval Postgraduate School, the Departments of Navy and Defense, and other branches of Government, as well as our professional and academic organizations.

Master of Science in Management program includes a group of curricula designed to prepare officers for specialized line and staff assignments related to military decision-making, policy setting, and improvement of management and organizational effectiveness. Each curriculum is an interdisciplinary program, which integrates mathematics, financial management, economics, behavioral science, management theory, operations/systems analysis, and a sub-specialty concentration to provide an in-depth understanding of the process by which the defense mission is accomplished. Currently, courses are offered in the following specialties: [Ref. 26]

1. Transportation Logistics Management (813),
2. Transportation Management (814),
3. Acquisition and Contract Management (815),
4. Systems Acquisition Management (816),
5. Defense Systems Analysis-Coast Guard, Marines, & DoD Civilians (817),

6. Defense Systems Management-International Students (818),
7. Systems Inventory Management (819),
8. Material Logistics Support Management (827),
9. Financial Management (837),
10. Manpower Systems Analysis (847),
11. Shore Installation Management (877).

Master of Science degree in these curricula is an 18-21 month program depending on the specific curriculum. The typical course of study for SM students is depicted in Table 5, which also includes the relationships among the courses and specialties offered by SM Department. Graduate level common core courses are shown in Table 6.

To prepare students for the main program, the common core courses (Table 6), are given in two phases:

1. Management Fundamentals,
2. Graduate Level Core.

Statistical/quantitative background material is provided in the sequence as:

1. MA 2300 Mathematics for Management,
2. OS 3101 Statistical Analysis for Management,
3. OS 3006 Operations Research for Management.

Currently, Math and Operations Research Departments give these courses.

Table 5

SYSTEMS MANAGEMENT DEPARTMENT'S MASTER OF SCIENCE IN MANAGEMENT PROGRAM
TYPICAL COURSE OF STUDY

Courses	813	814	815	816	817	818	819	827	837	847	877
EO 4011 Systems Eng. For Acquisition Managers				X							
IS 2010 Introduction to Information Technology	X	X	X	X	X	X	X	X	X	X	X
IS 3185 Management of Information Technology	X	X	X	X	X	X	X	X	X	X	X
MA 2300 Mathematics for Management	X	X	X	X	X	X	X	X	X	X	X
MN 2111 Seminar in MPT Issues I										X	
MN 2112 Seminar in MPT Issues II										X	
MN 2150 Financial Accounting	X	X	X	X	X	X	X	X	X	X	X
MN 2302 Seminar for Acquisition and Contracting			X								
MN 2303 Seminar for Program Management				X							
MN 3001 Economics for Defense Managers	X	X	X	X	X	X	X	X	X	X	X
MN 3105 Organization and Management	X	X	X	X	X	X	X	X	X	X	X
MN 3111 Personnel management Processes	*	X			X		*	*		X	*
MN 3140 Microeconomic Theory	X	X	X	X	X	X	X	X	X	X	X
MN 3154 Financial Management in the Armed Forces	X	X					X	X	X		X
MN 3155 Financial Mgmt for Acquisition Managers			*	X							
MN 3161 Managerial Accounting	X	X	X	X	X	X	X	X	X	X	X
MN 3172 Public Policy and Budgeting	X	X	X	X	X	X	X	X	X	X	X
MN 3303 Principles of Acquisition and Contract Mgmt			X								
MN 3304 Contract Pricing & Negotiations			X								
MN 3309 Acquisition of Embedded Weapon Syst.S/W				X							
MN 3312 Contract Law			X								
MN 3315 Acquisition Mgmt and Contract Admin.			X								
MN 3331 Principles of Systems Acquisition & Program Mgmt	X	X		X			*	X	X		*
MN 3333 Managerial Communications Skills	X	X	X	X	X	X	X	X	X	X	X
MN 3370 Seminar on Leadership in Supply Chain Mgmt	X	X					X	X			
MN 3371 Contracts Mgmt & Administration	X	X		X			X	X			X
MN 3372 Material Logistics	X	X					X	X			
MN 3373 Domestic Transportation Management	X	X						*			
MN 3374 Production Management	*	*					*	X			
MN 3375 Materials Handling Systems Design		X					*	*			
MN 3377 Inventory Management	X							*			

Table 5

Courses	813	814	815	816	817	818	819	827	837	847	877
MN 3384 Principles of Acquisition Production and Quality Mgmt			*	X							
MN 3402 Seminar in Base Installation Management											X
MN 3471 Installation Management in the AF											X
MN 3760 Manpower Economics										X	
MN 3902 Intro to SAS for Statistics										X	
MN 4105 Strategic Management	X	X	X	X	X	X	X	X	X	X	X
MN 4106 Manpower, Personnel Policy Analysis										X	
MN 4110 Multivariate Manpower Data Analysis I										X	
MN 4111 Multivariate Manpower Data Analysis II										X	
MN 4115 Training Foundations and Management										X	
MN 4118 Modelling Decisin Support in MPTA										X	
MN 4122 Planning and Control									*		
MN 4125 Managing Plan Change in Complex Org.					X						X
MN 4145 Policy Analysis	X	X	X	X	X	X	X	X			X
MN 4151 Internal Control and Auditing			*						X		
MN 4152 Corporate Financial Management			*						*		
MN 4153 Seminar in Financial Management									X		
MN 4159 Financial Reporting and Analysis									*		
MN 4161 Management Control Systems					X				X		X
MN 4162 Cost Management			*						X		
MN 4301 Contracting for Major Systems			X								
MN 4302 Defense Resource Policy and Mgmt									*		
MN 4305 Defense Technology Policy			*	*					*		
MN 4307 Program Management Policy & Control				X							
MN 4310 Logistics Engineering	*	*	*	X			X	X			
MN 4312 Simulation Modeling for Decision-Making							X				
MN 4333 Media Relations and Interorganizational Comm											X
MN 4371 Acquisition and Contracting Policy			X								
MN 4372 Seminar in Acquisition and Contract Mgmt			*	*							
MN 4373 International Transportation Management	X	X									
MN 4376 Defense transportation System	X	X									
MN 4470 Strategic Planning and Policy for Logistics	*		*	*				*			
MN 4472 Base Installation Issues											X
MN 4761 Applied Manpower Analysis										X	

Table 5

Courses	813	814	815	816	817	818	819	827	837	847	877
MN 4790 Managing Diversity in Military										X	
NW 3230 Strategy and Policy	X	X	X	X	X		X	X	X	X	X
OA 3401 Human Factors in Systems Design I								*			
OA 3501 Inventory I							X	*			
OA 3610 Introductin to Naval Logistics		*									
OA 4302 Reliability &Weapons Systems Effectiveness								*			
OA 4303 Sample Inspection and Quality Assurance								*			
OA 4501 Seminar in Supply Systems							X				
OA 4611 Joint and Combined Logistics	X	*									
OA 4702 Cost Estimation				*					*		
OS 3006 Operations Research for Management	X	X	X	X	X	X	X	X	X	X	X
OS 3101 Statistical Analysis for Management	X	X	X	X	X	X	X	X	X	X	X
OS 3302 Quality Assurance & Reliability Methods				X							
OS 4602 Test and Evaluation Management				X							
OS 4701 Manpower and Personnel Models										X	

X denotes that the course is mandatory for that curriculum.
* denotes that the course is optional for that curriculum.

Table 6

SYSTEMS MANAGEMENT DEPARTMENT'S MASTER OF SCIENCE IN MANAGEMENT PROGRAM FUNDAMENT
GRADUATE LEVEL COMMON CORE COURSES

Management Fundamentals	813	814	815	816	817	818	819	827	837	847	877
MN 2150 Financial Accounting	X	X	X	X	X	X	X	X	X	X	X
MN 3001 Economics for Defense Managers	X	X	X	X	X	X	X	X	X	X	X
MN 3333 Managerial Communications Skills	X	X	X	X	X	X	X	X	X	X	X
IS 2010 Introduction to Information Technology	X	X	X	X	X	X	X	X	X	X	X
MA 2300 Mathematics for Management	X	X	X	X	X	X	X	X	X	X	X
MN 3161 Managerial Accounting	X	X	X	X	X	X	X	X	X	X	X
MN 3140 Microeconomic Theory	X	X	X	X	X	X	X	X	X	X	X
OS 3101 Statistical Analysis for Management	X	X	X	X	X	X	X	X	X	X	X
MN 3105 Organization and Management	X	X	X	X	X	X	X	X	X	X	X
Graduate Level Core											
MN 3172 Public Policy and Budgeting	X	X	X	X	X	X	X	X	X	X	X
MN 4145 Policy Analysis*	X	X	X	X	X	X	X	X	MN4163	MN 4106	X
MN 4105 Strategic Management	X	X	X	X	X	X	X	X	X	X	X
IS 3185 Management of Information Technology	X	X	X	X	X	X	X	X	X	X	X
OS 3006 Operations Research for Management	X	X	X	X	X	X	X	X	X	X	X
NW 3230 Strategy and Policy	X	X	X	X	X	X	X	X	X	X	X

* This course is replaced by MN 4163 Decision, Cost and Policy Analysis in Financial Management (837) and by MN 4106 Manpower, Personnel, and Policy Analysis in Manpower System Analysis (847)

B. CONDUCT OF A SURVEY

1. Methodology

The objectives and research questions for this thesis were discussed in Chapter I Sections A and B. The next step is to answer those questions. Because the principal aim of this research is to integrate statistical/quantitative background material with decision making modeling for master's level analytical courses, literature review of top management programs and conducting a survey among NPS SM faculty members were chosen as the primary methodologies to elicit such information. Multiple data sources and methods were used to enhance the reliability of these findings.

Literature review data were supplemented with questionnaire data from a structured survey. Both qualitative and quantitative analyses were used to analyze the data collected. The overall research design is depicted in Figure 1.

2. Research Questions

A questionnaire consisting of four sections was given to the survey subjects, selected SM faculty members. These sections are:

- Background Information of Respondents,
- Mathematics Topics,
- Statistics Topics,
- Operations Research Topics.

The survey questions were developed from the syllabuses of the related courses. Appendix A contains the actual questionnaire, which was used to obtain responses from Systems Management faculty members.

The questions in Section 1 are mainly checklist type. The third question in this section is an open-ended question designed to get information about the courses that the respondent teaches at NPS. The later sections of the questionnaire mainly use graphic scale questions, while having open-ended questions at the end of each section to give opportunity to the respondents to add their comments.

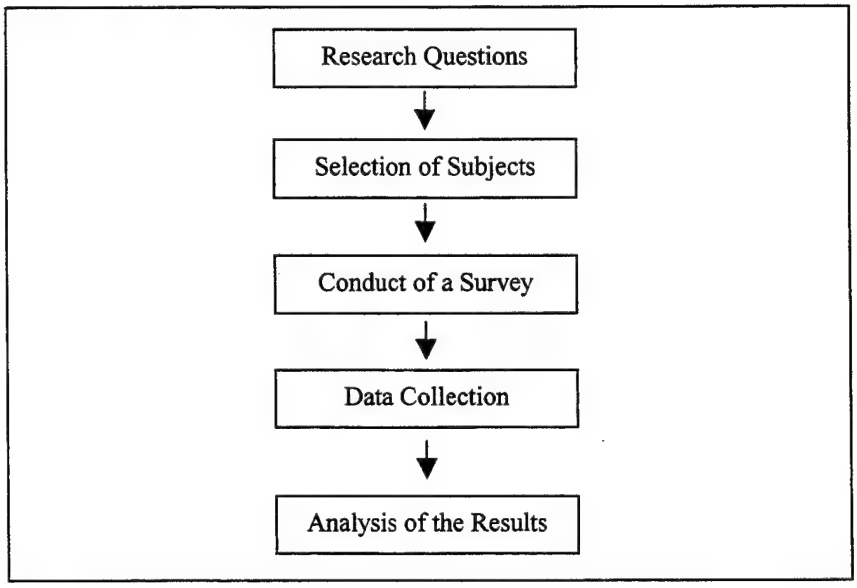

Figure 1. Research Design.

3. Selection of the Subjects

All SM faculty members were selected to be the survey respondents. The selection process consisted of two steps. In the first step, an initial questionnaire, which was designed to determine if the proposed analytical courses affect the courses taught by

the respondents, was sent to all SM faculty members. Appendix B contains this initial questionnaire.

In the second step, we determined the subjects who responded to the initial questionnaire that the students needed statistical/quantitative tools in their courses.

4. Conduct of the Survey

After selecting the subjects, the detailed questionnaire in Appendix A was sent to the subjects via our thesis advisor—Prof. Shu S. Liao, with a memorandum the questionnaire attached. The memorandum is depicted in Appendix C. The responded questionnaires were returned to the mailbox of our thesis advisor, which then were handed to us for the analysis.

5. Results of the Survey

The initial questionnaire was given to all the SM faculty members. Twenty-nine professors responded to the initial questionnaire.

Seven professors out of 29 who responded to the initial questionnaire indicated that students do not need statistical/quantitative tools in their courses. 13 professors indicated that their courses do not require any course work with statistical/quantitative tools, but basic understanding of these tools is expected from the students. Of the 29 professors who responded the initial questionnaire, nine professors indicated that students need statistical/quantitative tools in their courses. Seven mentioned that they felt current analytical course offerings in math, stat, and quantitative methods (operations research) do not adequately prepare the students for their courses.

Then the detailed questionnaire was given to these nine professors. Six of them responded to the detailed questionnaire. These six professors (three professors, two associate professors, and one assistant professor) teach 18 different courses in Systems Management curricula. The areas of teaching responsibilities of these six professors are financial management and budgeting (two professors), logistics and transportation management (two professors), manpower systems analysis (one professor), and economics and resource allocation analysis (one professor). The results of the both initial and detailed questionnaires are summarized in Tables 7 and 8 below.

# OF PROFESSORS TO WHOM QUESTIONNAIRE WAS SENT	# OF PROFESSORS WHO RESPONDED			
	No Need	*Basic Understanding*	*Need*	
			Comfortable	*Uncomfortable with Current Status*
All SM Faculty	7	13	2	7
			9	
	29			

Table 7. Results of the Initial Questionnaire.

The raw data, presented by question number with the frequency per answer are shown in Appendix D.

# OF PROFESSORS TO WHOM QUESTIONNAIRE WAS SENT	# OF PROFESSORS WHO RESPONDED			TEACHING RESPONSIBILITIES OF WHO RESPONDED			
	Professor	Associate Professor	Assistant Professor	Finance and Budgeting	Logistics and Transportation	Manpower	Economics
9	3	2	1	2	2	1	1
	6			6			

Table 8. Results of the Detailed Questionnaire.

C. SUMMARY

In this chapter, we provided the current situation at the Naval Postgraduate School's (NPS) Systems Management Department (SM) in terms of mission and curriculum. By looking at the common core courses at eleven SM curricula, we observed that the statistical/quantitative background material for the core analytical courses is provided in three courses, which are

- MA 2300 Mathematics for Management,
- OS 3101 Statistical Analysis for Management,
- OS 3006 Operations Research for Management.

This statistical/quantitative course sequence is almost the same as that of top management schools', which have a statistical/quantitative course sequence as:

- Probability and Statistics,
- Quantitative Methods for Managers,

- Data, Models, and Decisions,
- Operations/Production Management.

However, these top management schools' statistical/quantitative course sequence generally has four courses, providing more statistical/quantitative background material than those of NPS. Furthermore, the aim of the graduate education at NPS is the same as of the top management schools in terms of graduate students' quality. In addition, there are not much of selection criteria for students as top management schools. Due to the time constraint and diversity of students—thus the diversity of analytical backgrounds at NPS, we wanted to determine

1. Whether current contents of courses at NPS provides sufficient statistical/quantitative background material for the core curriculum,
2. If not, what the contents of these courses should be?

To accomplish this, we conducted a survey among the SM faculty members. The results of the survey have been discussed in this chapter.

The next chapter analyzes the results of the survey.

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V. SURVEY ANALYSIS

This chapter presents an analysis of the survey conducted among the Systems Management faculty members in order to design courses, which would integrate statistical/quantitative background material into research methodology and decision-modeling courses. We will analyze the raw data presented in previous chapter in determining the contents of statistical/quantitative courses that will serve as the foundations for Systems Management's analytical courses.

A. DATA ANALYSIS

For analysis of the survey, we will use the mean value and standard deviation. Each section in the survey has main topics and detailed sub-topics. Each sub-topic is regarded as a question and scaled to three categories as *Don't Need, Familiarity,* and *Working Knowledge* to describe the students' need for the topic. For analysis purposes we weighted each category by giving the value of "0" (zero) for *Don't Need*, "1"(one) for *Familiarity*, and "2" (two) for *Working Knowledge* answers. Then we calculated the mean and the standard deviation for each question in the survey based on the computation of the frequency count presented in previous chapter.

In order to determine threshold for cutoff points, we chose a 3-3 basis, and we will use this basis with the response distributions of each question for later analysis. The cutoff points are calculated as follows:

Question#	No Need (0)	Familiarity (1)	Working Knowledge (2)	Mean
1	3	3	0	0.5
2	0	3	3	1.5

Table 9. The Computation of Cutoff Points for 3-3 Basis.

As shown in Table 9, we decided that any topic having a response distribution of three-familiarity—50 percent of the responses, and three-no need—the other 50 percent of the responses, and below is regarded as potentially unnecessary. This cutoff point gives us a mean value of 0.5 as shown in Table 9. Along the same line, the topics with a response distribution of three-working knowledge level—50 percent of responses and three-familiarity—the other 50 percent and above are regarded as important. This cutoff point comes to a mean value of 1.5 as in Table 9. For each question, any mean value over 1.5 is regarded as important and should be taught in working knowledge level without any doubt.

As the nature of the weighted values for each category indicates, the topics having a mean value between 1.0 and 1.5 should be taught at least at familiarity level. This means that decision modeling courses require the topic at the familiarity level and above which has the weighted value of 1.0. The topics having a mean value between 0.5 and 1.0 are questionable and represent a gray area to be further analyzed.

1. Mathematics Topics

Table 10 presents the main mathematics topics and each topic's mean value sorted in descending order of importance. Graph 1 is the chart illustration of Table 10. Table 11 shows the means and standard deviations for each subtopic in detail.

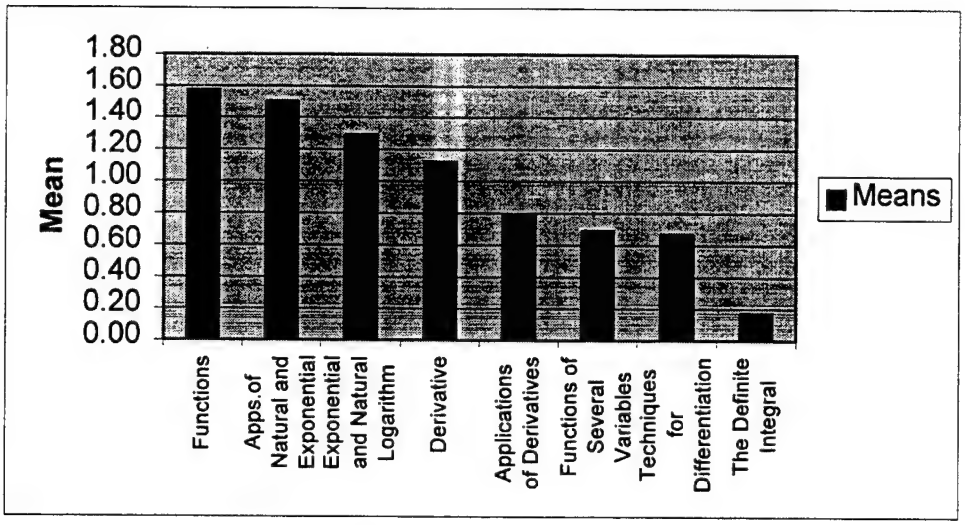
There are eight main topics in mathematics to be analyzed. We are going to analyze each topic and its subtopics in detail. First we are going to analyze main topics starting from the highest mean value and we will continue with the smaller ones. The criterion to be used has been discussed above as 3-3 basis and response distribution.

Question#	Topics	Mean	SD
1	Functions	1.57	0.53
6	App. Natural and Exponential Log. Functions	1.50	0.52
5	Exponential and Natural Logarithm Functions	1.29	0.86
2	Derivative	1.12	0.80
3	Applications of Derivatives	0.79	0.88
8	Functions of Several Variables	0.69	0.95
4	Techniques for Differentiation	0.67	0.98
7	The Definite Integral	0.17	0.38

Table 10. Mathematics Topics.

a. Functions

As shown in Table 10, functions as a main topic should be covered in working knowledge level, since it has a mean value of 1.57. Analyzing the subtopics according to mean values, we see that following topics should be covered in working knowledge level because these topics have a mean value above 1.5. These topics are:



Graph 1. Chart Illustration of Table 10.

- Functions and their graphs,
- Linear functions,
- Polynomial and rational functions,
- Power functions,
- Exponents and power functions,
- Functions and graphs applications.

The following subtopics having mean values between 1 and 1.5 should be covered at least familiarity level. These are:

- Quadratic functions,
- The absolute value function,
- The algebra of functions,
- Zeros of functions-the quadratic formula and factoring.

Questions	*No Need*	*Familiarity*	*Working Knowledge*	*Mean*	*SD*
	(0)	*(1)*	*(2)*		
1.Functions					
a. Functions and their graphs	0	1	5	1.8	0.41
b. Linear functions	0	1	5	1.8	0.41
c. Quadratic functions	1	2	3	1.3	0.82
d. Polynomial and rational functions	0	2	4	1.7	0.52
e. Power functions	0	3	3	1.5	0.55
f. The absolute value function	0	5	1	1.2	0.41
g. The algebra of functions	0	4	2	1.3	0.52
h. Zeros of functions-The quadratic formula and factoring	0	4	2	1.3	0.52
i. Exponents and power functions	0	1	5	1.8	0.41
j. Functions and graphs in applications	0	1	5	1.8	0.41
2.The Derivative					
a. The slope of a straight line	0	2	4	1.7	0.52
b. The slope of a curve at a point	0	3	3	1.5	0.55
c. The derivative	1	2	3	1.3	0.82
d. Limits and the derivative	2	2	2	1.0	0.89
e. Differentiability and continuity	3	2	1	0.7	0.82
f. The second derivative	3	2	1	0.7	0.82
g. The derivatives as a rate of change	2	2	2	1.0	0.89
3. Applications of Derivatives					
a. Describing the graphs of functions	3	2	1	0.7	0.82
b. The first and second derivative rules	4	0	2	0.7	1.03
c. Curve sketching	2	3	1	0.8	0.75
d. Optimization	3	0	3	1.0	1.10
4. Techniques for Differentiation					
a. The product and quotient rules	4	0	2	0.7	1.03
b. The chain rule and the general power rule	4	0	2	0.7	1.03
5. The Exponential and Natural Logarithm Functions					
a. Exponential functions	1	1	4	1.5	0.84
b. The natural logarithm function	1	1	4	1.5	0.84
c. The derivative of ln x	3	1	2	0.8	0.98
d. Properties of natural logarithm function	1	2	3	1.3	0.82
6. App. of The Exponential and Natural Logarithm Functions					
a. Exponential growth and decay	0	3	3	1.5	0.55
b. Compound interest	0	3	3	1.5	0.55
7. The Definite Integral					
a. Anti-differentiation	5	1	0	0.2	0.41
b. Areas and riemann sums	5	1	0	0.2	0.41
c. Definite integrals and fundamental theorem	5	1	0	0.2	0.41
8. Functions of Several Variables					
a. Multivariable functions	4	0	2	0.7	1.03
b. Level curves	4	0	2	0.7	1.03
c. Partial derivatives	4	0	2	0.7	1.03
d. Interpretation of a partial derivative as a rate of change	4	0	2	0.7	1.03
e. Relative extrema of functions of two variables	4	0	2	0.7	1.03
f. The method of Lagrange multipliers	3	1	2	0.8	0.98

Table 11. Statistics of Mathematics Subtopics with Response Distribution.

b. Applications of Exponential and Natural Logarithmic Functions

The applications of exponential and natural logarithmic functions should be covered in working knowledge level based on the analysis. The analyses of subtopics are discussed hereafter. There are two subtopics to be covered under this topic and both of them should be covered in working knowledge level. These subtopics are:

- Exponential growth and decay,
- Compound interest.

c. Exponential and Natural Logarithm Functions

The topic of exponential and natural logarithmic functions needs coverage of at least at familiarity level, but the analysis of subtopics shows different coverage levels. This is the reason for this topic to have a smaller mean value than its applications. The subtopics, which should be covered at working knowledge level, are:

- Exponential functions,
- The natural logarithm function.

The subtopic, which should be covered at least at familiarity level, is P*roperties of Natural Logarithm Function*. The subtopic of *The Derivative of ln x* with a mean value of 0.8 requires further analysis since it is in the gray area and it is subject to the time and the approval of the professor of the course.

d. Derivative

The topic of derivatives should be covered at least at familiarity level. The general use of the derivative is in economics courses. The following subtopics should be covered at working knowledge level:

- The slope of a straight line,
- The slope of a curve at a point.

However, subtopics of *The Derivative, The Derivatives as a Rate of Change,* and *Limits and The Derivative* should be covered at least at familiarity level. The subtopics of *Differentiability and Continuity* and *The Second Derivative* are in the gray area and require further analysis.

e. Applications of Derivatives

The derivative and its applications have their use in economics courses and of little use in decision modeling courses. Consequently, the main topic of applications of derivatives with its subtopics of *Describing the Graphs of Functions, The First and Second Derivative Rules,* and *Curve Sketching* is in the gray area and requires further analysis. However, the subtopic of *Optimization* requires familiarity level coverage.

f. Functions of Several Variables

The main topic of functions of several variables with all its subtopics is in the gray area and requires further analysis. On the other hand, the main use of functions of several variables is in economics courses rather than decision modeling courses.

g. Techniques for Differentiation

This topic also has its uses in the economics courses. Similarly, the results of the survey show that it has a mean value of 0.67 and remains in the gray area near to the lower border with its all subtopics. There is no need for this topic in decision modeling courses.

h. The Definite Integral

The definite integral is not needed in any decision-making or economics courses. Therefore there is no need to cover this topic having the mean value of 0.2.

2. Statistics Topics

Table 12 presents the main statistics topics and each topic's mean value sorted in descending order of importance. Graph 2 is the chart illustration of Table 12. Table 13 shows the means and standard deviations (SD) for each subtopic.

There are ten main topics in statistics to be analyzed. We are going to analyze each topic and its subtopics in detail. First we are going to analyze the one with the

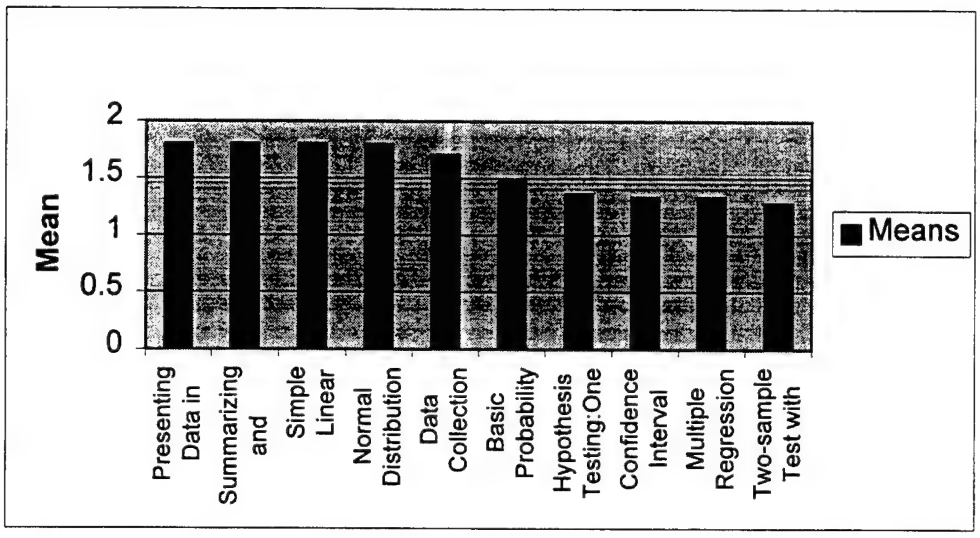
highest mean value and we will continue with the smaller ones. The criterion to be used has been discussed before as 3-3 basis with the response distribution. However, looking at the mean values for all the statistics topics, it is obvious to see that all the mean values are above 1.0. This means that all statistics topics are to be covered at least at familiarity level.

Question#	Topics	Mean	SD
2	Presenting Data in Tables and Charts	1.8	0.41
3	Summarizing and Describing Numerical Data	1.8	0.41
9	Simple Linear Regression and Correlation	1.8	0.41
5	Normal Distribution and Sampling Dist.	1.79	0.51
1	Data Collection and Excel	1.7	0.52
4	Basic Probability and Discrete Probability Dist.	1.47	0.74
7	Hypothesis Testing :One Sample Test	1.36	0.93
6	Confidence Interval Estimation	1.33	0.49
10	Multiple Regression Models	1.33	0.76
8	Two-sample Test with Numerical data	1.28	0.89

Table 12. Statistics Topics.

a. Presenting Data in Tables and Charts

Having the mean value of 1.8, presenting data in tables and charts should be covered at working knowledge level. When we look at the responses given to this question we see that five professors wanted this topic to be covered at working knowledge level while one professor wanted familiarity. So, there is no doubt for this topic that it should be covered at working knowledge level.



Graph 2. Chart Illustration of Table 12.

b. Summarizing and Describing Numerical Data

With the same distribution of answers as a, summarizing and describing numerical data has a mean value of 1.8—meaning that this topic should also be covered at working knowledge level without any doubt.

c. Simple Linear Regression and Correlation

With the same distribution of answers as a and b, simple linear regression and correlation has also a mean value of 1.8—meaning that this topic should also be covered at working knowledge level without any doubt.

d. Normal Distribution and Sampling Distribution

As a main topic, normal distribution and sampling distribution with the mean value of 1.79 should be covered at working knowledge level. When we analyze

Questions	*No Need*	*Familiarity*	*Working Knowledge*	*Mean*	*SD*
	(0)	*(1)*	*(2)*		
1. Data collection and excel	0	2	4	1.7	0.52
2. Presenting data in tables and charts	0	1	5	1.8	0.41
3. Summarizing and describing numerical data	0	1	5	1.8	0.41
4. Basic probability and discrete probability distributions					
a. Basic probability concepts	0	1	5	1.8	0.41
b. Conditional probability	0	1	5	1.8	0.41
c. Bayes' theorem	2	2	2	1.0	0.89
d. Binomial distribution	1	2	3	1.3	0.82
e. Poisson distribution	1	2	3	1.3	0.82
f. The probability distribution for a discrete random variable	1	1	4	1.5	0.84
5. Normal distribution and sampling distributions					
a. The normal distribution	0	1	5	1.8	0.41
b. Asssessing the normality assumption	0	1	5	1.8	0.41
c. Exponential distribution	0	1	5	1.8	0.41
d. Sampling distributions	1	0	5	1.7	0.82
6. Confidence interval estimation					
a. Confidence interval estimation of the mean	0	4	2	1.3	0.52
b. Confidence interval estimation for the proportion	0	4	2	1.3	0.52
c. Determining sample size	0	4	2	1.3	0.52
7. Fundemantals of hypothesis testing: one sample test					
a. Hypothesis-testing methodology	1	1	4	1.5	0.84
b. Z test of hypothesis for the mean	2	0	4	1.3	1.03
c. The p-value approach to hypothesis testing	2	0	4	1.3	1.03
d. Connection between confidence int. and hypothesis testing	2	0	4	1.3	1.03
e. One-tailed tests	2	0	4	1.3	1.03
f. T test of hypothesis for the mean	2	0	4	1.3	1.03
g. Z test of hypothesis for the proportion	2	0	4	1.3	1.03
8. Two-sample test with numerical data					
a. Comparing two independent samples:t tests for differences in two means	1	1	4	1.5	0.84
b. F tests for differences in two variances	2	1	3	1.2	0.98
c. Comparing two related samples:t test for the mean difference	2	1	3	1.2	0.98
9. Simple linear regression and correlation	0	1	5	1.8	0.41
10. Multiple regression models					
a. Solving the "normal equetions"	1	3	2	1.2	0.75
b.Residuals from Multiple regression;validating the assumptions	1	2	3	1.3	0.82
c. Hypothesis tests and CI for the coefficients in a MR	1	2	3	1.3	0.82
d. R-squared and goodness-of-fit	1	1	4	1.5	0.84
e. CI's for the predicted mean and individual values	1	2	3	1.3	0.82
f. Categorical variables in Multiple Regression	1	2	3	1.3	0.82

Table 13. Statistics of Statistics Subtopics with Response Distribution.

the subtopics according to their mean values, it is obvious that all have mean values above 1.7. This is far over our upper cutoff point of 1.5 and this means that all subtopics should be covered at working knowledge level too. These subtopics are:

- The normal distribution,
- Assessing the normality assumption,
- Exponential distribution, and
- Sampling distributions.

e. Data Collection and Excel

With the answer distribution of four-working knowledge and two-familiarity, data collection and excel has a mean value of 1.7. This topic is an important part of the decision modeling courses for the purposes of simulation, spreadsheet applications, which are main tools for decision-makers. With its importance and the high mean value it should be covered at working knowledge level.

f. Basic Probability and Discrete Probability Distribution

As a main topic, it has a mean value of 1.47—just below our upper cutoff point of 1.5. Regarding the different responses for the subtopics this topic should be divided in two phases—one of which is to be covered at working knowledge level and the other at familiarity level. The subtopics to be covered at working knowledge level are *Basic Probability Concepts, Conditional Probability,* and *The Probability Distribution*

for a Discrete Random Variable. The subtopics *Bayes' Theorem, Binomial Distribution,* and *Poisson distribution* should be covered at least at familiarity level with the least emphasis on Bayes' Theorem.

g. Fundamentals of Hypothesis Testing: One Sample Test

With the mean value of 1.36 the topic of Hypothesis testing should be covered at least at familiarity level according to our criterion. However, this topic is important and necessary for decision modeling courses. The reason for the mean value to be below 1.5 is the responses from the economics professors who say that there is no need for this topic in their courses. Consequently, this topic should be covered at working knowledge level with its all subtopics of:

- Hypothesis testing methodology,
- Z-test of hypothesis for the mean,
- The p-value approach to hypothesis testing,
- Connection between confidence interval and hypothesis testing,
- One-tailed tests,
- T-test of hypothesis for the mean,
- Z-test of hypothesis for the proportion.

h. Confidence Interval Estimation

The confidence interval estimation has a mean value of 1.33, which implies that it should be covered at least at familiarity level. All subtopics having a mean value of 1.33 and the same response distribution need this topic to be covered at least at familiarity level. These subtopics are:

- Confidence interval estimation of the mean,
- Confidence interval estimation for the proportion,
- Determining sample size.

i. Multiple Regression Models

The topic of multiple regression models having a mean value of 1.33 should be covered at least at familiarity level including all subtopics except the subtopic of *R-squared and goodness-of-fit*, which requires working level knowledge for the students. All other subtopics to be covered at least at familiarity level are:

- Solving the normal equations,
- Residual from multiple regression; validating the assumptions,
- Hypothesis tests and confidence interval for the coefficients in multiple regression,
- Confidence intervals for the predicted mean and individual values,
- Categorical variables in multiple regression.

j. Two-sample Test with Numerical Data

The topic of two-sample test with numerical data has the mean value of 1.28 implying that it should be covered at least at familiarity level. However, the subtopic, *Comparing two Independent Samples--T-tests for Differences in Two Means* needs working knowledge level coverage. The other subtopics, *F-tests for Differences in Two Variances,* and *Comparing Two Related Samples: T-test for The Mean Difference* need to be covered at least at familiarity level.

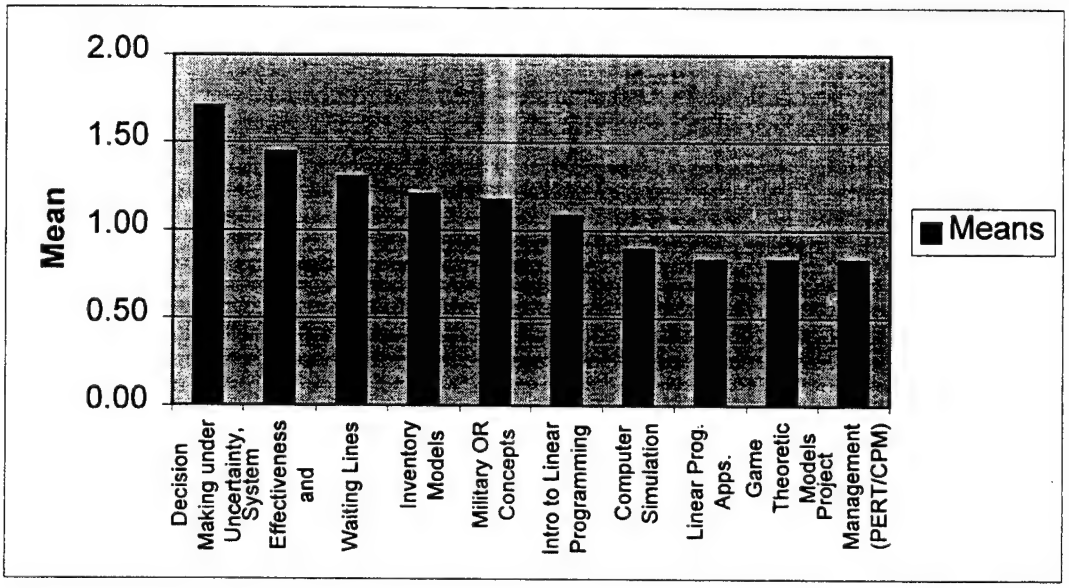
3. Operations Research Topics

Table 14 presents the main operations research topics and each topic's mean value sorted in descending order of importance. Graph 3 is the chart illustration of Table 14. Table 15 shows the means and standard deviations (SD) for each subtopic.

There are ten main topics in operations research to be analyzed. We are going to analyze each topic and its subtopics in detail. First we are going to analyze the one with the highest mean value and we will continue with the smaller ones. The criterion to be used has been discussed before as 3-3 basis with the response distribution. When we look at the mean values for all the topics, it is obvious to see all topics have mean values between 1.7 and 0.83. This means that more thorough analysis is necessary for determining the coverage level of each topic.

Question#	Topics	Mean	SD
4	Decision Making under Uncertainty, Certainty and Risk	1.70	0.52
9	System Effectiveness and Measures of Effectiveness	1.44	0.61
7	Waiting Lines	1.30	0.52
8	Inventory Models	1.20	0.75
1	Military OR Concepts	1.17	0.56
2	Introduction to Linear Programming	1.08	0.65
10	Computer Simulation	0.89	0.47
3	Linear Programming Applications	0.83	0.38
5	Game Theoretic Models	0.83	0.59
6	Project Management (PERT/CPM)	0.83	0.62

Table 14. Operations Research Topics.



Graph 3. Chart Illustration of Table 14.

a. Decision-Making Under Uncertainty, Certainty, and Risk

The topic of decision-making under uncertainty, certainty, and risk has a mean value of 1.7, which is above the upper cutoff point of 1.5 and required to be

covered at working knowledge level. Furthermore, this topic is a foundation for decision modeling courses and in-depth coverage is necessary.

b. System Effectiveness and Measures of Effectiveness

The topic of system effectiveness and measures of effectiveness (MOE) has a mean value of 1.44 implying that it should be covered at least at familiarity level. This topic is covered in depth in MN 4145 Policy Analysis course, it raises the question of duplicate coverage in two different courses. However, according to the response distribution, the following subtopics having mean values between 1.5 and 2.0 should be covered at working knowledge level:

- Basic concepts,
- MOEs and system acquisition,
- Example of naval warfare MOEs,
- Case study of development and use of MOEs.

The subtopics of *Evaluation of Combat Effectiveness of C3 Systems,* and *Joint-Warfare MOEs and Hierarchies of Systems* having mean values of 1.0 and 1.2 respectively should be covered at least at familiarity level.

c. Waiting Lines

The topic of waiting lines, having a mean value of 1.3, needs to be covered at least at familiarity level. When we look at the response distribution to this

topic, it is easy to see that the big need for this topic is in MN 4310 Logistics Engineering and MN 3374 Production and Operations Management courses. Familiarity level of coverage is necessary for this topic in other decision-making courses. As a result, this topic should be covered at working knowledge level as long as the time and schedule is appropriate.

d. Inventory Models

The topic of inventory models' response distribution shows us that this topic should be covered at working knowledge level for all logistics courses, although, the other decision modeling courses needs this topic to be covered at least at familiarity level. With the mean value of 1.20 our survey also indicates that this topic should be covered at least at familiarity level.

e. Military OR Concepts

Having a mean value of 1.17, the topic of military OR concepts shows that it should be covered at least at familiarity level. Looking at the response distribution, we see that the subtopic of *Cost and Operational Effectiveness Analysis* should be covered at working knowledge level. The following subtopics having mean values between 1.0 and 1.5, however, should be covered at least at familiarity level:

- Uses of OR in DoD management,
- Systems effectiveness.

Questions	*No Need*	*Familiarity*	*Working Knowledge*	*Mean*	*SD*
	(0)	*(1)*	*(2)*		
1. Some military OR concepts of interest in Defense Acquisition					
a. Uses of OR in DoD Management	0	5	1	1.2	0.41
b. Systems effectiveness	0	4	2	1.3	0.52
c. Hierarchies of military systems	2	4	0	0.7	0.52
d. Cost and operational effectiveness analysis	0	3	3	1.5	0.55
2. Introduction to linear programming					
a. Model formulation	1	3	2	1.2	0.75
b.Graphical method of solution	1	4	1	1.0	0.63
c. Sensitivity analysis	1	3	2	1.2	0.75
d. Computer solution with computer software	1	4	1	1.0	0.63
3. Linear Programming applications					
a. Transportation problem	1	5	0	0.8	0.41
b. Assignment problem	1	5	0	0.8	0.41
c. Integer linear programming	1	5	0	0.8	0.41
4. Decision analysis					
a. Decision making under certainty/uncertainty/risk	0	2	4	1.7	0.52
5. Game theoretic models of two sided decision making with conflicting objectives					
a. Model formulation	1	3	2	1.2	0.75
b. Analytical solution of simple games	1	4	1	1.0	0.63
c. Computer solution via linear programming	2	4	0	0.7	0.52
d. Hedging against uncertainty	2	4	0	0.7	0.52
e. Gaming vs game theory(comparision of complementary obj.)	2	4	0	0.7	0.52
6. Project Management: PERT/CPM					
a. Project scheduling with known activity times	1	4	1	1.0	0.63
b. Project scheduling with uncertain activity times	1	4	1	1.0	0.63
c. LP model for crashing decisions	3	3	0	0.5	0.55
7. Waiting lines	0	4	2	1.3	0.52
8. Inventory Models					
a. Inventory models	1	3	2	1.2	0.75
9. System effectiveness and measures of effectiveness (MOEs)					
a. Basic concepts	0	2	4	1.7	0.52
b. MOEs and system acquisition	0	2	4	1.7	0.52
c. Example of naval warfare MOEs	0	3	3	1.5	0.55
d. Case study of development and use of MOEs	0	2	4	1.7	0.52
e. Evaluation of combat effectiveness of C3 systems	1	4	1	1.0	0.63
f. Joint-warfare MOEs and hierarchies of systems	1	3	2	1.2	0.75
10. Computer simulation					
a. Simulation of business systems	1	4	1	1.0	0.63
b. Demonstration of business simulation	1	5	0	0.8	0.41
c. Applications of modeling and simulation in DoD (training, analysis, and system acquisition)	1	5	0	0.83	0.41

Table 15. Statistics of OR Subtopics with Response Distribution.

The subtopic of *Hierarchies of Military Systems* having a mean value of 0.7 remains in the gray area and is subject to further analysis.

On the other hand, the comments of the respondents indicate that all the subtopics except *Uses of OR in DoD Management* should not be covered in OR courses. Instead, SM department should teach these topics more thoroughly.

f. Introduction to Linear Programming

There is not much of a discussion on this topic. By looking at the response distribution and the mean value of 1.08, the topic of introduction to linear programming should be covered at least at familiarity level with its all subtopics, which are:

- Model formulation,
- Graphical method of solution,
- Sensitivity analysis,
- Computer solution with computer software.

g. Computer Simulation

Although the mean value of the topic of computer simulation is 0.87 indicating that it remains in the gray area, looking at the response distribution shows that this topic is needed at least at familiarity level for decision modeling courses. The reason for this topic to have such a low mean value is that this topic is not needed in economics courses. The subtopics, which are shown below, should be covered at least at familiarity level. These subtopics are:

- Simulation of business systems,

- Demonstration of business simulation,
- Applications of modeling and simulation in DoD (training, analysis, and system acquisition).

h. Linear Programming Applications

Although the mean value of the topic of linear programming applications is 0.87 indicating that it remains in the gray area, looking at the response distribution shows that this topic is needed at least at familiarity level for decision modeling courses. The reason for this topic to have such a low mean value is that this topic is not needed in economics courses. The subtopics, which are shown below, should be covered at least at familiarity level. These subtopics are:

- Transportation problem,
- Assignment problem,
- Integer linear programming.

i. Game Theoretic Models

The topic of game theoretic models with its mean value of 0.83 remains in the gray area and further analysis is necessary for this topic. However, looking at the response distribution shows that the subtopics of *Model Formulation* and *Analytical Solution of Simple Games* should be covered at least at familiarity level, while the other

subtopics of *Computer Solution via Linear Programming, Hedging Against Uncertainty,* and *Gaming vs. Game Theory* still remain in the gray area and require further analysis.

j. Project Management (PERT/CPM)

The topic of project management with its mean value of 0.83 remains in the gray area and requires more analysis. However, the response distribution shows that this topic is needed at familiarity level in decision modeling courses. Again the reason for this low mean value is the no need responses from economics professors. Looking at the subtopics, *Project Scheduling with Known Activity Times,* and *Project Scheduling with Uncertain Activity Times* should be covered at least at familiarity level, while the subtopic of *LP Model for Crashing Decisions* remains in the gray area and requires further analysis.

B. CONCLUSION

In this chapter, we analyzed the survey results presented in Chapter 4. For the analysis purpose, we used the mean values and standard deviations of all questions. In order to interpret mean values and standard deviations, we set a selection model of 3-3 basis with the response distributions of each question. Based on this basis, we determined our cutoff points for the coverage level of topics. Any topic with a mean value above 1.5 is regarded as important and should be taught in working knowledge level without any doubt. Along the same line, any topic with a mean value under 0.5 is regarded as potentially unnecessary and should not be taught. The topics having a mean value

between 1.0 and 1.5 should be taught at least at familiarity level. The topics having a mean value between 0.5 and 1.0 are questionable and represent a gray area to be further analyzed. The term "gray area", which is used for the topics having mean values between 0.5 and 1.0, requires further analysis. That is, further decision process should be made among SM faculty members in order to decide the coverage level of those topics. While doing so, course sequence, time constraint, and overall curricula should be considered.

Earlier in the chapter, we analyzed each topic in depth for each course. A summary of this analysis is depicted in Table 16, 17 and 18 for the course contents of MA 2300, OS 3101, and OS 3006 respectively.

The Coverage Levels of Math Topics

Topics	Coverage Level
1.Functions	Working Knowledge
a. Functions and their graphs	Working Knowledge
b. Linear functions	Working Knowledge
c. Quadratic functions	Familiarity
d. Polynomial and rational functions	Working Knowledge
e. Power functions	Working Knowledge
f. The absolute value function	Familiarity
g. The algebra of functions	Familiarity
h. Zeros of functions-The quadratic formula and factoring	Familiarity
i. Exponents and power functions	Working Knowledge
j. Functions and graphs in applications	Working Knowledge
2.The Derivative	Familiarity
a. The slope of a straight line	Working Knowledge
b. The slope of a curve at a point	Working Knowledge
c. The derivative	Familiarity
d. Limits and the derivative	Familiarity
e. Differentiability and continuity	Gray area
f. The second derivative	Gray area
g. The derivatives as a rate of change	Familiarity
3. Applications of Derivatives	Gray area
a. Describing the graphs of functions	Gray area
b. The first and second derivative rules	Gray area
c. Curve sketching	Gray area
d. Optimization	Familiarity
4. Techniques for Differentiation	No need
a. The product and quotient rules	No need
b. The chain rule and the general power rule	No need
5. The Exponential and Natural Logarithm Functions	Familiarity
a. Exponential functions	Working Knowledge
b. The natural logarithm function	Working Knowledge
c. The derivative of ln x	Gray area
d. Properties of natural logarithm function	Familiarity
6. App. of The Exponential and Natural Logarithm Functions	Working Knowledge
a. Exponential growth and decay	Working Knowledge
b. Compound interest	Working Knowledge
7. The Definite Integral	No need
a. Anti-differentiation	No need
b. Areas and riemann sums	No need
c. Definite integrals and fundamental theorem	No need
8. Functions of Several Variables	Gray area
a. Multivariable functions	Gray area
b. Level curves	Gray area
c. Partial derivatives	Gray area
d. Interpretation of a partial derivative as a rate of change	Gray area
e. Relative extrema of functions of two variables	Gray area
f. The method of Lagrange multipliers	Gray area

Table 16. The Coverage Levels of Math Topics.

The Coverage Levels of Statistics Topics

Topics	Coverage Level
1. Data collection and excel	Working Knowledge
2. Presenting data in tables and charts	Working Knowledge
3. Summarizing and describing numerical data	Working Knowledge
4. Basic probability and discrete probability distributions	Familiarity
a. Basic probability concepts	Working Knowledge
b. Conditional probability	Working Knowledge
c. Bayes' theorem	Familiarity
d. Binomial distribution	Familiarity
e. Poisson distribution	Familiarity
f. The probability distribution for a discrete random variable	Working Knowledge
5. Normal distribution and sampling distributions	Working Knowledge
a. The normal distribution	Working Knowledge
b. Assessing the normality assumption	Working Knowledge
c. Exponential distribution	Working Knowledge
d. Sampling distributions	Working Knowledge
6. Confidence interval estimation	Familiarity
a. Confidence interval estimation of the mean	Familiarity
b. Confidence interval estimation for the proportion	Familiarity
c. Determining sample size	Familiarity
7. Fundamentals of hypothesis testing: one sample test	Working Knowledge
a. Hypothesis-testing methodology	Working Knowledge
b. Z test of hypothesis for the mean	Working Knowledge
c. The p-value approach to hypothesis testing	Working Knowledge
d. Connection between confidence int. and hypothesis testing	Working Knowledge
e. One-tailed tests	Working Knowledge
f. T test of hypothesis for the mean	Working Knowledge
g. Z test of hypothesis for the proportion	Working Knowledge
8. Two-sample test with numerical data	Familiarity
a. Comparing two independent samples; tests for differences	
in two means	Working Knowledge
b. F tests for differences in two variances	Familiarity
c. Comparing two related samples; test for the mean difference	Familiarity
9. Simple linear regression and correlation	Working Knowledge
10. Multiple regression models	Familiarity
a. Solving the "normal equations"	Familiarity
b. Residuals from Multiple regression; validating the assumptions	Familiarity
c. Hypothesis tests and CI for the coefficients in a MR	Familiarity
d. R-squared and goodness-of-fit	Working Knowledge
e. CI's for the predicted mean and individual values	Familiarity
f. Categorical variables in Multiple Regression	Familiarity

Table 17. The Coverage Levels of Statistics Topics.

The Coverage Levels of OR Topics

Topics	Coverage Level
1. Some Mil. OR concepts of interest in Def. Acquisition	Familiarity*
a. Uses of OR in DoD Management	Familiarity
b. Systems effectiveness	Familiarity*
c. Hierarchies of military systems	Gray Area*
d. Cost and operational effectiveness analysis	Working Knowledge*
2. Introduction to linear programming	Familiarity
a. Model formulation	Familiarity
b. Graphical method of solution	Familiarity
c. Sensitivity analysis	Familiarity
d. Computer solution with computer software	Familiarity
3. Linear Programming applications	Familiarity
a. Transportation problem	Familiarity
b. Assignment problem	Familiarity
c. Integer linear programming	Familiarity
4. Decision analysis	Working Knowledge
a. Decision making under certainty/uncertainty/risk	Working Knowledge
5. Game theoretic models	Gray Area
a. Model formulation	Familiarity
b. Analytical solution of simple games	Familiarity
c. Computer solution via linear programming	Gray Area
d. Hedging against uncertainty	Gray Area
e. Gaming vs. game theory (comparison of complementary obj.)	Gray Area
6. Project Management: PERT/CPM	Familiarity
a. Project scheduling with known activity times	Familiarity
b. Project scheduling with uncertain activity times	Familiarity
c. LP model for crashing decisions	Gray Area
7. Waiting lines	Working Knowledge
8. Inventory Models	Working Knowledge
a. Inventory models	Working Knowledge
9. System effectiveness and measures of effectiveness (MOEs)	Familiarity
a. Basic concepts	Working Knowledge
b. MOEs and system acquisition	Working Knowledge
c. Example of naval warfare MOEs	Working Knowledge
d. Case study of development and use of MOEs	Working Knowledge
e. Evaluation of combat effectiveness of C3 systems	Familiarity
f. Joint-warfare MOEs and hierarchies of systems	Familiarity
10. Computer simulation	Familiarity
a. Simulation of business systems	Familiarity
b. Demonstration of business simulation	Familiarity
c. Applications of modeling and simulation in DoD	Familiarity
(Training, analysis, and system acquisition)	

Table 18. The Coverage Levels of OR Topics.

- These topics should not be taught in OR course, instead they should be taught by SM faculty.

VI. CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the main findings and provides comprehensive answers to the research questions established in Chapter I. Recommendations are also included for future implementation of these findings in SM Department.

A. CONCLUSIONS

The following conclusions, attempted to provide comprehensive answers to the research questions, have been grouped as they were established in Chapter I, Section B. In order to reach the answer for our primary question, we developed secondary questions and followings are the comprehensive answers to these questions. Our primary question (research question # 1) was "what should the core quantitative and statistical courses in an MBA program and sequence and contents of these courses?". The answer to our primary question will be the aggregation of all the comprehensive answers of secondary questions.

Research question # 2 What are the requirements for management education in terms of AACSB and NASPAA standards?

All schools share a common purpose—the preparation of students to enter useful professional and societal lives. Interaction among students and faculty accomplishes this purpose most directly. Accordingly, the accreditation review focuses on a school's clear determination of its mission, development of its faculty, planning of its curricula, and delivery of its instruction. In these activities, each school must achieve and demonstrate

an acceptable level of performance consistent with its overall mission while satisfying AACSB/NASPAA standards. Standards set demanding but realistic thresholds, challenge schools to pursue continuous improvement, and provide guidance for improvement in master's level educational programs. As part of each school's effort to prepare its students for future careers, the school should provide a total educational experience that emphasizes conceptual reasoning, problem-solving skills, and preparation for life-long learning. These preparation efforts are especially important to students with limited background and experience.

Given all these requirements, the standards of both AACSB and NASPAA have been discussed in detail in Chapter II. Having accreditation from both agencies NPS satisfies these standards.

Research question # 3 What are the analytical contents of top management schools?

First, we determined the top schools in management education according to USN&WR graduate schools ranking. We picked the top ten schools from these lists and searched their MBA programs for the core courses and then came up with the sequence and contents of common core statistical/quantitative courses.

Second, we researched their programs. As we researched the programs, we saw that all the programs are two-year programs. However, the degree requirements are different for each school. Most of the programs start with a pre-term preparation program—three-four week program, which is designed to begin building teams and

address the quantitative and computer skills to ensure that students master skills and conceptual frameworks that will enhance and inform their learning throughout the curriculum. The first year of all MBA programs, which is designed to give the core courses, establishes a basic understanding of the functional responsibilities of an organization. During the second year of the program, students integrate concepts learned in the first year and take electives in the area of interests while completing all degree requirements.

All the core courses of all MBA programs are given in a sequence, as building blocks one on top of the other. Although course names differ from school to school, looking back at the programs we analyzed, we found that there is a common sequence of the statistical/quantitative courses as follows:

1. Probability and Statistics,
2. Quantitative Methods for Managers,
3. Data, Models, and Decisions,
4. Operations/Production Management.

The contents of these courses are described below.

1. Probability and Statistics

This course teaches students the fundamental principles of probability and statistics, with special emphasis on how these principles can be applied to business decision-making problems. The course covers basic tools for summarizing numerical

data, the laws of probability, Bayes' Theorem, discrete and continuous random variables (with special emphasis on the binomial, Poisson, exponential, and normal distributions), expected value and variance, point estimation of means and proportions, confidence intervals for means and proportions, hypothesis testing involving means and proportions, and the basic elements of statistical decision theory. The course illustrates these concepts using examples drawn primarily from the business world.

Later the course develops methods for analyzing statistical relationships involving several variables. Techniques studied in the course are useful for a variety of business applications in accounting, finance, marketing, production and other areas. The course emphasizes formulating models and using them for decision-making prediction. Topics include assessing the accuracy of coefficient estimates and predictions (interval estimation and hypothesis testing), and the more general problem of assessing the suitability of a model (specification analysis). The course involves extensive hands-on work with state-of-the-art software and data from variety of real-world applications.

2. Quantitative Methods

This course covers fundamental tools for quantitative analysis in the management sciences. Topics include linear algebra, nonlinear optimization, linear programming, integer programming, and simulation. Emphasis is placed on linear programming, particularly on modeling business applications and on sensitivity analysis. The course follows a practical spreadsheet-based approach to provide hands-on experience with software such as excel solver.

3. Data, Models and Decisions

This course introduces the fundamental concepts and techniques for analyzing risk and formulating sound decisions in uncertain environments. The course considers the use of two key statistical methodologies: regression analysis and experimentation. Regression analysis is a ubiquitous tool that permeates most of applied statistics. This course considers the application of regression in various contexts. The use of regression diagnostics and various graphical displays supplements the basic numerical summaries and provides insight into the validity of the modeling approach.

The coverage of experimentation introduces the notion of a statistical experiment. It is shown how a manager can design an experiment that will yield reliable, appropriate answers to various business questions, such as how to combine factors to produce the highest quality-manufacturing scheme. The course also introduces the statistical methods used in the analysis of data from experiments. These methods, collectively known as the analysis of variance, provide an important addition to the standard suite of regression techniques.

Specific important topics covered include least squares estimation, residuals and outliers, tests and confidence intervals, correlation and autocorrelation, collinearity, and randomization, multiple regression, basic time series. The presentation relies upon computer software for most of the needed calculations, and the resulting style focuses on construction of models, interpretation of results, and critical evaluation of assumptions.

4. Operations/Production Management

The production and distribution of services and manufactured goods is a complex task involving the management of material, information, technology and people. When properly managed operations can be a source of competitive advantage, resulting in high quality customized goods produced and delivered in a timely manner at minimal total cost. This course demonstrates models and practices that enable a company to achieve these objectives. Topics include: supply chain management, inventory and materials management, production planning and control, productivity improvements, quality control, JIT, flexible manufacturing, capacity allocation, forecasting, and resource planning. Current issues such as global supply chains and the Internet are also discussed. Cases supplement the lectures.

Research question # 4 Why do we need to integrate decision-making models with quantitative background material?

Decisions made by the organizational managers and leaders directly affect the output of their product or service. Therefore, it is important that management education should allow the leaders to make intelligent, appropriate and well-timed managerial decisions. Decision-making process involves a number of analytical tools and computer applications. These skills are to be given in management education. However, without the sufficient statistical/quantitative background material, building up analytical decision-making tools is almost impossible. That is, statistical/quantitative background material is the foundation for analytical decision-making tools. As a result, integration of decision-

making models with statistical/quantitative background material is of vital importance. This importance is well balanced in top management schools by offering four different statistical/quantitative courses as the foundation of their core decision-making modeling courses. On the other hand, this foundation at NPS is currently being provided by only three service courses, which have been the subject of our research.

Furthermore, student selection criteria are relatively high and indicated by high GMAT scores and rejection rates at top management schools. Although Academic Profile Code and detailer screening ensure the student quality at NPS, these requirements are not as strong as those of top management schools.

In the light of the discussion above, a prescreening, which we conducted among SM faculty members, indicated that the decision-making modeling courses required statistical/quantitative material. The prescreening also indicated that the current analytical course offerings in Math, Statistics and Operations Research do not adequately prepare students for decision-making modeling courses.

Research question # 5 What are the most appropriate course sequence and contents for the proposed courses?

The main purpose of our research was to answer this question. For this purpose we conducted a survey among the Systems Management faculty members in order to design courses, which would integrate statistical/quantitative background material into research methodology and decision-making modeling courses. The analysis of this survey has been provided with the sequence and contents of these courses in Chapter V.

B. RECOMMENDATIONS

1. In order to maintain the needed quality and managerial perspective, the service courses—MA 2300 Mathematics for Management, OS 3101 Statistical Analysis for Management, and OS 3006 Operations Research for Management should be redesigned so that the duplication of some topics and potentially unnecessary topics are eliminated. In addition, by redesigning these courses, the emphasis on each topic could be arranged so that these topics could be given in adequate depth—not more or less than what is needed. In the current situation, as our survey indicated there are topics which are not needed at all, and there are topics which are duplicated in follow on courses, and as a result SM faculty time and energy are wasted. The highly correlated program will certainly attribute the students at NPS in understanding and applying the decision-making models in real life.

2. Systems Management faculty members should teach these courses so that the statistical/quantitative tool acquisition is integrated with managerial perspective. Generally, other department faculty members have substantially different data analysis experience, and teach their courses as a poor textbook course failing to think from a managerial perspective.

3. Turkish Army Academy, which will start to offer graduate education and Ph.D. programs, may benefit from the results of this research to establish the foundations for the integration of statistical/quantitative background material with decision-making modeling courses.

C. AREAS FOR FUTURE RESEARCH

The authors identify one major area requiring further research area, which would be helpful to strengthen, change, or weaken some of the answers provided by this thesis to the research questions established in Chapter I, Section B. This area relates to the topics, which had mean values between 0.5 and 1.0 in the survey—defined as the "gray area" in our analysis. Similar techniques used in this thesis and the consensus of faculty members on the contents of the courses and the coverage levels of the topics in the "gray area" could be utilized for further integration process of statistical/quantitative background material with decision-making modeling courses.

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APPENDIX A. GRADUATE EDUCATION ANALYTICAL BACKGROUND REQUIREMENTS QUESTIONNAIRE

We are Murat Ozdemir and Kadir Ozyurek, 1st LT of Turkish Army. We are currently working on a joint thesis entitled "An Analysis of Integration of Decision-Making Modeling with Statistical/Quantitative Background for Masters Level Analytical Courses".

The purpose of this questionnaire is to collect data for designing courses, which would integrate statistical/quantitative background material into research methodology and decision modeling courses. Your answers will assist us in determining the contents of statistical/quantitative courses that will serve as the foundations for Systems Management's analytical courses. These statistical/quantitative courses are currently MA 2300 Mathematics for Management, OS 3101 Statistical Analysis for Management, and OS 3006 Operations Research for Management.

Your response will remain confidential. No effort will be made to identify you. Your individual answers to these questions will not be given to anyone in any organization.

The information you provide will be combined with the other SM faculty members for analysis. This survey includes four sections:

1. Background Information of Respondents,
2. Mathematics Topics,
3. Statistics Topics,
4. Operations Research Topics.

Your assistance in this effort is appreciated. Please return this survey to Prof. Shu S. Liao's mailbox ASAP.

SECTION 1 BACKGROUND INFORMATION OF RESPONDENTS

The following three questions are designed to obtain some general information about the respondents to be used for statistical purposes.

1. What is your academic title? (Please check one)

   __ Professor

   __ Associate professor

   __Assistant professor

   __Senior lecturer

   __Lecturer

   __Other (e.g. military instructor, etc.)

2. Which of the following best describe your area of teaching responsibility? (Check all applicable ones)

   __Acquisition, Contracting, and Project Management

   __Financial Management and Budgeting

   __Logistics and Transportation Management

   __Manpower Systems Analysis

   __Economics and Resource Allocation Analysis

   __General Management, Strategic Planning & Policy Analysis

3. What courses have you been teaching at NPS? Please specify the course number & title.

   _____

   _____

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SECTION 2 MATHEMATICS TOPICS

The following topics are listed in the OS 3101 course syllabus. Please check the box that best describes your students' need for the topic.If you feel that there are additional topics necessary for your course(s) but not covered in this survey, please indicate them in the space provided below.

Do your students need .....in your course?

	Don't Need	Familiarity (exposure)	Working knowledge	For which area the topic is needed
1.Functions				
a. Functions and their graphs.....	☐	☐	☐	.....
b. Linear functions.....	☐	☐	☐	.....
c. Quadratic functions.....	☐	☐	☐	.....
d. Polinomial and rational functions.....	☐	☐	☐	.....
e. Power functions.....	☐	☐	☐	.....
f. The absolute value function.....	☐	☐	☐	.....
g. The algebra of functions.....	☐	☐	☐	.....
h. Zeros of functions-The quadratic formula and factoring.....	☐	☐	☐	.....
i. Exponents and power functions.....	☐	☐	☐	.....
j. Functions and graphs in applications.....	☐	☐	☐	.....
2.The Derivative				
a. The slope of a straight line.....	☐	☐	☐	.....
b. The slope of a curve at a point.....	☐	☐	☐	.....
c. The derivative.....	☐	☐	☐	.....
d. Limits and the derivative.....	☐	☐	☐	.....
e. Differentiability and continuity.....	☐	☐	☐	.....
f. The second derivative.....	☐	☐	☐	.....
g. The derivatives as a rate of change.....	☐	☐	☐	.....
3. Applications of Derivatives				
a. Describing the graghs of functions.....	☐	☐	☐	.....
b. The first and second derivative rules.....	☐	☐	☐	.....
c. Curve sketching.....	☐	☐	☐	.....
d. Optimization.....	☐	☐	☐	.....
4. Techniques for Differentiation				
a. The product and quotient rules	☐	☐	☐	.....
b. The chain rule and the general power rule.....	☐	☐	☐	.....
5. The Exponential and Natural Logarithm Functions				
a. Exponential functions.....	☐	☐	☐	.....
b. The natural logarithm function.....	☐	☐	☐	.....
c. The derivative of ln x.....	☐	☐	☐	.....
d. Properties of natural logarithm function.....	☐	☐	☐	.....
6. Applications of The Exponential and Naturel Logarithm Functions				
a. Exponential growth and decay.....	☐	☐	☐	.....
b. Compound interest.....	☐	☐	☐	.....

	Don't Need	Familiarity (exposure)	Working knowledge	For which area the topic is needed
7. The Definite Integral				
a. Antidifferentiation.....	☐	☐	☐	.....
b. Areas and riemann sums.....	☐	☐	☐	.....
c. Definite integrals and fundemental theorem.....	☐	☐	☐	.....
8. Functions of Several Variables				
a. Multivariable functions.....	☐	☐	☐	.....
b. Level curves.....	☐	☐	☐	.....
c. Partial derivatives.....	☐	☐	☐	.....
d. Interpretation of a partial derivative as a rate of change.....	☐	☐	☐	.....
e. Relative extrema of functions of two variables.....	☐	☐	☐	.....
f. The method of lagrange multipliers.....	☐	☐	☐	.....

9. Additional topics you would like to add and comments

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SECTION 3 STATISTICS TOPICS

The following topics are listed in the OS 3101 course syllabus. Please check the box that best describes your students' need for the topic.If you feel that there are additional topics necessary for your course(s) but not covered in this survey, please indicate them in the space provided below.

Do your students need .....in your course?	No Need	Familiarity (exposure)	Working knowledge	For which area the topic is needed
1. Data collection and excel	☐	☐	☐	.....
2. Presenting data in tables and charts	☐	☐	☐	.....
3. Summarizing and describing numerical data	☐	☐	☐	.....
4. Basic probability and discrete probability distributions				.....
a. Basic probability concepts	☐	☐	☐	.....
b. Conditional probability	☐	☐	☐	.....
c. Bayes' theorem	☐	☐	☐	.....
d. Binomial distribution	☐	☐	☐	.....
e. Poisson distribution	☐	☐	☐	.....
f. The probability distribution for a discrete random variable	☐	☐	☐	.....
5. Normal distribution and sampling distributions				
a. The normal distribution	☐	☐	☐	.....
b. Asssessing the normality assumption	☐	☐	☐	.....
c. Exponential distribution	☐	☐	☐	.....
d. Sampling distributions	☐	☐	☐	.....
6. Confidence interval estimation				
a. Confidence interval estimation of the mean	☐	☐	☐	.....
b. Confidence interval estimation for the proportion	☐	☐	☐	.....
c. Determining sample size	☐	☐	☐	.....
7. Fundemantals of hypothesis testing: one sample test				
a. Hypothesis-testing methodology	☐	☐	☐	.....
b. Z test of hypothesis for the mean	☐	☐	☐	.....
c. The p-value approach to hypothesis testing	☐	☐	☐	.....
d. Connection between confidence int. and hypothesis testing	☐	☐	☐	.....
e. One-tailed tests	☐	☐	☐	.....
f. T test of hypothesis for the mean	☐	☐	☐	.....
g. Z test of hypothesis for the proportion	☐	☐	☐	.....
8. Two-sample test with numerical data				
a. Comparing two independent samples:t tests for differences	☐	☐	☐	.....
in two means	☐	☐	☐	.....
b. F tests for differences in two variances	☐	☐	☐	.....
c. Comparing two related samples:t test for the mean difference	☐	☐	☐	.....
9. Simple linear regression and correlation	☐	☐	☐	

	No Need	Familiarity (exposure)	Working knowledge	For which area the topic is needed
10. Multiple regression models				
a. Solving the "normal equetions".....	☐	☐	☐	.....
b.Residuals from Multiple regression;validating the assumptions	☐	☐	☐	.....
c. Hypothesis tests and CI for the coefficients in a MR.....	☐	☐	☐	.....
d. R-squared and goodness-of-fit.....	☐	☐	☐	.....
e. CI's for the predicted mean and individual values.....	☐	☐	☐	.....
f. Categorical variables in Multiple Regression.....	☐	☐	☐	.....

11. Additional topics you would like to add and comments

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SECTION 4 OPERATIONS RESEARCH TOPICS

The following topics are listed in the OS 3101 course syllabus. Please check the box that best describes your students' need for the topic.If you feel that there are additional topics necessary for your course(s) but not covered in this survey, please indicate them in the space provided below.

Do your students need .....in your course?	No Need	Familiarity (exposure)	Working knowledge	For which area the topic is needed
1. Some military OR concepts of interest in Defense Acquisition				
a. Uses of OR in DoD Management.....	☐	☐	☐	.....
b. Systems effectiveness	☐	☐	☐	.....
c. Hierarchies of military systems.....	☐	☐	☐	.....
d. Cost and operational effectiveness analysis.....	☐	☐	☐	.....
2. Introduction to linear programming				
a. Model formulation.....	☐	☐	☐	.....
b.Graphical method of solution.....	☐	☐	☐	.....
c. Sensitivity analysis.....	☐	☐	☐	.....
d. Computer solution with computer software.....	☐	☐	☐	.....
3. Linear Programming applications				
a. Transportation problem.....	☐	☐	☐	.....
b. Assignment problem.....	☐	☐	☐	.....
c. Integer linear programming.....	☐	☐	☐	.....
4. Decision analysis				
a. Decision making under certainty/uncertainty/risk.....	☐	☐	☐	.....
5. Game theoretic models of two sided decision making with conflicting objectives				
a. Model formulation.....	☐	☐	☐	.....
b. Analytical solution of simple games.....	☐	☐	☐	.....
c. Computer solution via linear programming.....	☐	☐	☐	.....
d. Hedging against uncertainty.....	☐	☐	☐	.....
e. Gaming vs game theory(comparision of complementary obj.)	☐	☐	☐	.....
6. Project Management: PERT/CPM				
a. Project scheduling with known activity times.....	☐	☐	☐	.....
b. Project scheduling with uncertain activity times.....	☐	☐	☐	.....
c. LP model for crashing decisions.....	☐	☐	☐	.....
7. Waiting lines	☐	☐	☐	
8. Inventory Models				
a. Inventory models.....	☐	☐	☐	.....

	No Need	Familiarity (exposure)	Working knowledge	For which area the topic is needed
9. System effectiveness and measures of effectiveness(MOEs)				
a. Basic concepts.....	☐	☐	☐	.....
b. MOEs and system acquisition.....	☐	☐	☐	.....
c. Example of naval warfare MOEs.....	☐	☐	☐	.....
d. Case study of development and use of MOEs.....	☐	☐	☐	.....
e. Evaluation of combat effectiveness of C3 systems.....	☐	☐	☐	.....
f. Joint-warfare MOEs and hierarchies of systems.....	☐	☐	☐	.....
10. Computer simulation				
a. Simulation of business systems.....	☐	☐	☐	.....
b. Demonstration of business simulation.....	☐	☐	☐	.....
c. Applications of modeling and simulation in DoD..... (training, analysis, and system acquisition)	☐	☐	☐	.....

11. Additional topics you would like to add and comments

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APPENDIX B. MEMORANDUM FOR INITIAL QUESTIONNAIRE

MEMORANDUM February 29, 2000

From: Shu Liao
To: SM Faculty
Subj: Student's Statistical and Quantitative Preparation for Your Courses

During our last round of core course review exercise, one strong desire expressed by those for the analytical track was to integrate statistical and quantitative background material in application areas such as research methodology, analytical analysis, and modeling. For example, we can teach hypothesis testing when we teach data analysis for business research.

We are trying to see if we can make this happen by redesigning analytical courses for our curriculum core to incorporate the analytical tools we desire for the core and the necessary quantitative/statistical background material.

Because of our faculty's diverse background, the analytical tools may not be needed by everyone. The purpose of this short questionnaire is to determine if the proposed analytical courses will affect the courses you have been teaching or may teach in the future.

Please check one of the following three boxes, and return the questionnaire to my mailbox ASAP.

Your Name, please: _____

☐ My courses do not need any statistical/quantitative background.

☐ My courses do not require student to do any course work with statistical/quantitative tools, but basic understanding of these tools is expected.

☐ Students need statistical/quantitative tools in my courses.

If you check this box, do you feel current analytical course offerings in Math, Stat, and Quantitative Methods adequately prepare the students for your courses?

Yes: _____ No: _____

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APPENDIX C. MEMORANDUM FOR DETAILED QUESTIONNAIRE

MEMORANDUM March 24, 2000

From: Shu Liao
To:
Subj: Questionnaire on Analytical Material

Keebom and I are directing a student thesis with the purpose of drawing up a blue print for integrating statistical and quantitative material in application areas as research methodology, analytical analysis and modeling.

The enclosed questionnaire is the follow-up of my earlier questionnaire on student's statistical and quantitative preparation for your courses. Your response to my earlier questionnaire indicates that students need statistical/quantitative tools in your courses. We can use your input in determining what topical areas we need to cover for our curricula and what can be eliminated. Note that we are evaluating the usefulness of what are being taught as well as topics that we need but were not taught.

I realize that the questionnaire is long and detailed, but the issues facing us are so critical that we have no alternative but to identify those, whose courses are at stake and ask for their help. You are one of the few we identified. So, please help and complete the enclosed questionnaire. We would appreciate it very much if you can complete it before the new quarter begins so we will have sufficient time to complete the task.

Please return the completed questionnaire to my box.

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APPENDIX D. RAW DATA BY QUESTION AND FREQUENCY ANSWERED (MATHEMATICS)

Questions	*No Need*	*Familiarity*	*Working Knowledge*
1.Functions			
a. Functions and their graphs	0	1	5
b. Linear functions	0	1	5
c. Quadratic functions	1	2	3
d. Polinomial and rational functions	0	2	4
e. Power functions	0	3	3
f. The absolute value function	0	5	1
g. The algebra of functions	0	4	2
h. Zeros of functions-The quadratic formula and factoring	0	4	2
i. Exponents and power functions	0	1	5
j. Functions and graphs in applications	0	1	5
2.The Derivative			
a. The slope of a straight line	0	2	4
b. The slope of a curve at a point	0	3	3
c. The derivative	1	2	3
d. Limits and the derivative	2	2	2
e. Differentiability and continuity	3	2	1
f. The second derivative	3	2	1
g. The derivatives as a rate of change	2	2	2
3. Applications of Derivatives			
a. Describing the graghs of functions	3	2	1
b. The first and second derivative rules	4	0	2
c. Curve sketching	2	3	1
d. Optimization	3	0	3
4. Techniques for Differentiation			
a. The product and quotient rules	4	0	2
b. The chain rule and the general power rule	4	0	2
5. The Exponential and Natural Logarithm Functions			
a. Exponential functions	1	1	4
b. The natural logarithm function	1	1	4
c. The derivative of ln x	3	1	2
d. Properties of natural logarithm function	1	2	3
6. App. of The Exponential and Naturel Logarithm Functions			
a. Exponential growth and decay	0	3	3
b. Compound interest	0	3	3
7. The Definite Integral			
a. Antidifferentiation	5	1	0
b. Areas and riemann sums	5	1	0
c. Definite integrals and fundemental theorem	5	1	0
8. Functions of Several Variables			
a. Multivariable functions	4	0	2
b. Level curves	4	0	2
c. Partial derivatives	4	0	2
d. Interpretation of a partial derivative as a rate of change	4	0	2
e. Relative extrema of functions of two variables	4	0	2
f. The method of lagrange multipliers	3	1	2

RAW DATA BY QUESTION AND FREQUENCY ANSWERED (STATISTICS)

Questions	*No Need*	*Familiarity*	*Working Knowledge*
1. Data collection and excel	0	2	4
2. Presenting data in tables and charts	0	1	5
3. Summarizing and describing numerical data	0	1	5
4. Basic probability and discrete probability distributions			
a. Basic probability concepts	0	1	5
b. Conditional probability	0	1	5
c. Bayes' theorem	2	2	2
d. Binomial distribution	1	2	3
e. Poisson distribution	1	2	3
f. The probability distribution for a discrete random variable	1	1	4
5. Normal distribution and sampling distributions			
a. The normal distribution	0	1	5
b. Asssessing the normality assumption	0	1	5
c. Exponential distribution	0	1	5
d. Sampling distributions	1	0	5
6. Confidence interval estimation			
a. Confidence interval estimation of the mean	0	4	2
b. Confidence interval estimation for the proportion	0	4	2
c. Determining sample size	0	4	2
7. Fundemantals of hypothesis testing: one sample test			
a. Hypothesis-testing methodology	1	1	4
b. Z test of hypothesis for the mean	2	0	4
c. The p-value approach to hypothesis testing	2	0	4
d. Connection between confidence int. and hypothesis testing	2	0	4
e. One-tailed tests	2	0	4
f. T test of hypothesis for the mean	2	0	4
g. Z test of hypothesis for the proportion	2	0	4
8. Two-sample test with numerical data			
a. Comparing two independent samples:t tests for differences			
in two means	1	1	4
b. F tests for differences in two variances	2	1	3
c. Comparing two related samples:t test for the mean difference	2	1	3
9. Simple linear regression and correlation	0	1	5
10. Multiple regression models			
a. Solving the "normal equetions"	1	3	2
b.Residuals from Multiple regression;validating the assumptions	1	2	3
c. Hypothesis tests and CI for the coefficients in a MR	1	2	3
d. R-squared and goodness-of-fit	1	1	4
e. CI's for the predicted mean and individual values	1	2	3
f. Categorical variables in Multiple Regression	1	2	3

RAW DATA BY QUESTION AND FREQUENCY ANSWERED (OPERATIONS RESEARCH)

Questions	*No Need*	*Familiarity*	*Working Knowledge*
1. Some military OR concepts of interest in Defense Acquisition			
a. Uses of OR in DoD Management	0	5	1
b. Systems effectiveness	0	4	2
c. Hierarchies of military systems	2	4	0
d. Cost and operational effectiveness analysis	0	3	3
2. Introduction to linear programming			
a. Model formulation	1	3	2
b.Graphical method of solution	1	4	1
c. Sensitivity analysis	1	3	2
d. Computer solution with computer software	1	4	1
3. Linear Programming applications			
a. Transportation problem	1	5	0
b. Assignment problem	1	5	0
c. Integer linear programming	1	5	0
4. Decision analysis			
a. Decision making under certainty/uncertainty/risk	0	2	4
5. Game theoretic models of two sided decision making with conflicting objectives			
a. Model formulation	1	3	2
b. Analytical solution of simple games	1	4	1
c. Computer solution via linear programming	2	4	0
d. Hedging against uncertainty	2	4	0
e. Gaming vs game theory(comparision of complementary obj.)	2	4	0
6. Project Management: PERT/CPM			
a. Project scheduling with known activity times	1	4	1
b. Project scheduling with uncertain activity times	1	4	1
c. LP model for crashing decisions	3	3	0
7. Waiting lines	0	4	2
8. Inventory Models			
a. Inventory models	1	3	2
9. System effectiveness and measures of effectiveness(MOEs)			
a. Basic concepts	0	2	4
b. MOEs and system acquisition	0	2	4
c. Example of naval warfare MOEs	0	3	3
d. Case study of development and use of MOEs	0	2	4
e. Evaluation of combat effectiveness of C3 systems	1	4	1
f. Joint-warfare MOEs and hierarchies of systems	1	3	2
10. Computer simulation			
a. Simulation of business systems	1	4	1
b. Demonstration of business simulation	1	5	0
c. Applications of modeling and simulation in DoD (training, analysis, and system acquisition)	1	5	0

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INITIAL DISTRIBUTION LIST

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